PB-215 314

ANNUAL REVIEW OF LITERATURE (1950) ON: I. STREAM POLLUTION, II. ANALYTICAL METHODS, III. RADIOACTIVE WASTES

M. B. Ettinger, et al

Environmental Health Center
Cincinnati, Ohio

March 1951

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

437 T239

PB 215 314

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
Cincinnati, Ohio
March 1951

ANNUAL REVIEW OF LITERATURE (1950)

on

I. STREAM POLLUTION

by

M. B. Ettinger
Paul Haney
Paul Kabler
Max Katz
Maurice LeBosquet
C. C. Ruchhoft
John Wiley

II. ANALYTICAL METHODS

by

W. Allan Moore

III. RADIOACTIVE WASTES

by

L. R. Setter

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

TABLE OF CONTENTS

		Page
Review of Literature - Stream Pollution		
Abatement and Control	(83 references)	1 - 9
Bacteriology	(14 references)	10 - 13
Biology	(28 references)	14 - 29
Chemistry	(19 references)	30 - 32
Oxygen Sag and Self Purification	(7 references)	33 - 36
Stream Surveys and Studies	(10 references)	37 - 40
Review of Literature - Analytical Methods	(76 references)	41 - 53
Review of Literature - Radioactive Wastes	(47 references)	54 - 63

The list of references on each subject follows the last page listed for the subject.

Review of Literature on Stream Pollution - 1950

Abatement and Control

A National Technical Task Committee on Industrial Wastes, sponsored by the U. S. Public Health Service and the Water Pollution Control Advisory Board, was established (2,3). It consists of about 30 members with some 250 technicians forming the working committees (4). Immediate tasks of the committee are: (a) assembly of source list of existing treatment and control practices, (b) listing existing research activities on industrial wastes, and (c) enumerating problems in treatment of industrial wastes.

Consideration is being given to amending the Water Pollution Control Act (Public Law 845) to: (a) increase the loan provisions to $5,000,000 for individual projects, (b) reduce interest rates on loans from two to one per cent, and (c) increase annual total loan appropriations from $22,500,000 to $50,000,000. A separate bill by Senator Byrnes would allow income tax deductions for amounts paid for industrial waste treatment work on a five year depreciation basis.

The Engineers Joint Council formed a task committee to establish a National Water Policy to aid the President's

"Temporary Water Resources Commission"[5][6]. The coordinating committee recommended greatly reduced federal spending on water resources development and would limit federal projects to those self-liquidating and self-supporting. On stream pollution the committee recommended that federal participation be limited to administration of existing laws,[7] and the research and guidance upon which sound local laws may be based.

In the dispute of education vs. enforcement in securing pollution abatement, the former was advocated by a much greater extent[8]. The Public Health Service was quite active in this field, preparing and distributing two booklets: one, for the general public, entitled "Clean Water Is Everybody's Business",[9] and the other, for professional personnel, named "Guide to Source Material on Water Pollution Control"[10]. Water pollution reports on the 16 major drainage basins which include the entire United States, are essentially complete at the present time[11]. These will be summarized into a national report. The research program in water pollution has also been expanded. Wright[69] states that studies are being conducted at Denver and by three

universties on pollution of irrigation waters. One editorial[14] expresses concern about the undermining of States' rights by Public Health Service action; however, Public Law 845 itself requires that no federal enforcement action may be taken without the request or consent of the authorities of the States involved and many articles indicate the extremely close liaison between Federal and State agencies[9][57].

In implementing the Water Pollution Control Act (Public Law 845), Congress appropriated[50] the following amounts for fiscal year 1951:

$750,000 for grants to States, municipalities or interstate agencies for planning.

$1,000,000 for allotment to States for investigation, research and surveys.

$1,500,000 for Public Health Service water pollution control activities.

$1,400,000 plus contract authorization for $2,400,000 for a new Public Health Service building at Cincinnati for research, training and studies of water pollution.

Interest-free loans of about $2,000,000 to 105 communities in the Ohio Valley for advance planning of

sewerage facilities was reported[12] but total figures for the United States were not available.

In England the Ministry of Health recommended passage of a new act to control pollution to replace the Rivers Pollution Act of 1870, but including provisions of the Salmon and Freshwater Fisheries Act of 1923[13].

In an editor's annual report[14], it is indicated that more success in stream pollution abatement will be attained with industries than with municipalities and stresses that municipal sewage treatment is a more important problem than industrial wastes. Municipalities, however, have already gone a long way while industries, discharging several times the volume and strength of wastes as municipal servers, have a far greater task ahead of them. In general, the Interstate Commissions are considering water pollution and its control on a more realistic basis than previously. Most of them now consider each stretch of stream as an individual problem, there being certain amounts and types of waste that the stream can handle by self-purification without damage. Consideration of water uses below points of discharge and the establishment

of attainable standards of water quality, then transposing to effluent qualities at each location provide the most effective approach.

In an A.W.W.A. Committee Report[1], a compilation of interstate compacts and commissions is presented. There are now 15 Congress-approved commissions and four informal agreements and agencies of which 33 states are members. Most of the compacts in the West deal with division of irrigation waters and Colorado belongs to eight such groups. In the East, they are largely for pollution abatement with New York acting in four compacts. A tabulation of basic laws on pollution by States is also given[18]. On surface waters, 29 states have agencies exercising some control, six have agencies with advisory powers only and 13 have none.

Cleary[49] states that the Ohio River Valley Water Sanitation Commission now has a budget of $100,000. The Commission is meeting with representatives of each of several industries to pool resources and expedite water pollution control[15]. Only 11 per cent of the cities over 5,000 population in the eight states have taken no action relative to providing sewage treatment[16].

The Interstate Commission on the Potomac River Basin expected a 1950 budget of about $38,000[54]. The

Commission is concentrating on the important problems around Washington, D. C., which has started expansions to cost an ultimate $11,500,000. Other communities in the area are planning enlarged or new plants.

Progress was temporarily handicapped by the State Auditor of West Virginia, who withheld funds for the Ohio River Valley Commission (17). Stillerman (66) states that the California and Indiana programs are also stymied by legal hurdles. A New Jersey court ruled legal the use of local authorities and sale of revenue bonds to construct sewerage works; (18) however, an Indiana court ruled that such authorities were not legal and construction work is stopped pending a State Supreme Court ruling (66).

Kentucky legislation established a Water Pollution Control Commission with six members giving it authority to establish water quality standards according to use and to issue abatement orders (19). New or strengthened pollution control legislation was provided during the 1949 legislative sessions in: Delaware, Indiana, Iowa, Illinois, Michigan, Ohio, South Dakota, Tennessee and Wisconsin (20, 21).

The Detroit Regional Planning Commission (22), the California Water Pollution Control Board (23), the New York State Joint Legislative Committee (24), the Maryland

Water Pollution Control Commission[59], and several others have proposed tentative standards for water quality on the basis of usage. A court case, based on the 1947 Maryland Law, resulted in an injunction against a sand and gravel company which was discharging 80 tons of solids per eight-hour day[25].

At a meeting of the Governor's Council in October, the Public Health Service presented a model act to assist in the establishment of uniform State laws on stream pollution. This act was prepared in close cooperation with State Health Departments and Water Pollution Control Boards, and was endorsed by the Council of State Governments[63]. The Federation of Sewage Works Association gave its program designed to stimulate immediate nation-wide steps to curtail stream pollution[26].

Stimulus since World War II has resulted in the completion of many municipal and district sewerage plans quite a few of which were placed under construction in 1950[27, 28, 29, 30, 31, 55, 60]. Contracts for public sewerage construction for the year amounted to $237,400,000. This represents an increase over 1949 of four per cent, as compared to an average increase for all types of public construction of 32 per cent.

A new term for waste treatment has been coined in California - water reclamation plants[53]. Sewage must all be treated to a pre-determined degree and the effluent is then discharged to recharge ground waters through stream channels or percolation beds. Rawn[64] reports that about six acres per M.G.D. of initial flow of treated effluent is required for San Gabriel Valley spreading grounds.

A liberal policy of accepting industrial wastes has been announced by Laboon[56] of the Allegheny Company Sanitary Authority. Acid mine drainage continues to be the major problem in the Ohio Valley, with an estimated 2,500,000 tons of acid yearly reaching the Ohio River[33].

The State of Washington set forth procedures for in-plant prevention and reduction of industrial waste discharges for various types of industries[68]. These methods are effective and frequently as important as the waste treatment plant itself. Fifteen pulp and paper mills in Washington, Wisconsin and Oregon were ordered to reduce pollution[34, 35]. The magnesium oxide process was proposed by one plant where pulp wood is floated in fresh water, but but would not be satisfactory for wood floated in salt water.[36] Oregon State College engineers recommended treatment of sulfite liquors by lagooning during the low water period as the only feasible method[37]. Murdock[61]

suggests that Tyler's proposal of 1942 (the installation of aerators in streams) be considered where an excess of oxidizable matter is present, as from sulfite pulp plants. It appears that if such treatment is successful in streams, it would be more economical in municipal sewage or industrial waste treatment plants where the wastes are less dilute.

Oesterle[62] describes a method of pumping abrasive wastes from a glass plant to a natural basin for thickening to eliminate the flow directly to the river. The biggest problem in the pebble phosphate industry, as described by Fuller[52], is silt which affects fish food and bottom life. The University of Florida is investigating lime precipitation of colloidal substances in the mine waters.

REFERENCES*

1. Amer. Water Works Assoc. Committee Report
"Basic Water Use Doctrines and State Water Control Agencies".
Jour. Amer. Water Works Assoc. 42, (8), 755-73 (1950)

2. Anon
"National Task Committee on Industrial Wastes".
This Journal, 22, 892 (1950)

3. Anon
"Industrial Waste Experts to Aid Abatement Drive".
Engineering News-Record, 144 (6) 27, (1950)

4. Anon
"Industry, U. S. Public Health Service Confer Next Week on Industrial Water Pollution".
Engineering News-Record, 144 (17), 29, (1950)

5. Anon
"Suggestions Sought on National Water Policy".
Engineering News-Record 144 (15), 26, (1950)

6. Anon
"Engineering Profession Invites Suggestions on National Water Policy".
Water and Sewage Works 97, 205 (1950)

7. Anon
"A National Water Policy Needed".
Civil Engineering, 20, 443-5 (1950)

8. Anon
"Sales Promotion in Pollution Abatement Editorial".
This Journal 22, 1246-47 (1950)

9. Anon
Public Health Service
"Clean Water Is Everybody's Business".
P.H.S. Publication #11, U.S. Govt. Printing Office, 26 pp. (1950)

10. Anon
Public Health Service
"Guide to Source Material on Water Pollution Control".
P.H.S. Division of Water Pollution Control, Washington 23 pp., (1950)

*Since this review was prepared for publication in Sewage and Ind. Wastes Jour. "This Journal" refers to the Sewage Works Journal.

11. Anon
"U.S. Public Health Service Will Issue First Basin Reports This Summer in Anti-Pollution Drive".
Engineering News-Record 144, 25 (1950)

12. Anon
"HHFA Loans Expedite Ohio Valley Pollution Control".
Civil Engineering 20, (10), 60 (1950)

13. Anon
"River Pollution Prevention".
The Surveyor 108, 745-57 (1949)

14. Anon
"Pollution Abatement Progress".
(Part of "1949-50 Annual Report on Techniques and Trends").
Engineering News-Record, 144, (12), 122-3 (1950)

15. Anon
"Steel, Pollution Men Agree on Waste Program".
Engineering News-Reocrd 144, (11), 25 (1950)

16. Anon
"Status of Municipal Treatment in Ohio Basin".
This Journal 22, 653 (1950)

17. Anon
"Court Upsets West Virginia Sanitation Pact".
Water and Sew. Works 97, 234 (1950)

18. Anon
"New Jersey Court O.K.'s Plan of Sewerage Authority".
Engineering News-Record, 145 (7), 29 (1950)

19. Anon
"Pollution Control Group Established by Kentucky".
Engineering News-Record 144, 27 (1950)

20. Anon
"Illinois Strengthens State Pollution Control Authority".
This Journal 22, 60 (1950)

21. Anon
"More States Tackle Stream Pollution".
This Journal 22, 355 (1950)

22. Anon
"Detroit's Stream Pollution Problem".
Engineering News-Record 144, 96 (1950)

23. Anon
"Here's A Way to Tackle Pollution Abatement".
Engineering News-Record 144, 42-44 (1950)

24. Anon
"Pollution Abatement Being Pushed Vigorously in New York State".
This Journal 97, 296 (1950)

25. Anon
"Maryland Pollution Commission Wins First Civil Court Action on Abatement".
Engineering News-Record 144, 30 (1950)
Also: This Journal 22, 903 (1950)

26. Anon
"Sewage Works Federation Passes Important Resolution".
Water and Sewage Works 97, 498 (1950)

27. Anon
"Cornerstone Is Laid for Owls Head Pollution Plant".
Civil Engineering 20, (7), 58 (1950)

28. Anon
"New Treatment Plant Will End Jamaica Bay Pollution".
Civil Engineering 20, (7), 60 (1950)

29. Anon
"Engineering Construction Contracts Reported to Engineering News-Record".
Engineering News-Record 146, (2), 27 (1951)

30. Anon
"Florida Reports Progress in Abating Stream Pollution
Civil Engineering 20, (3), 62 (1950)

31. Anon
"Pennsylvania Orders Cleanup on Susquehanna River".
Water and Sewage Works 97, 166 (1950)

32. Anon
"Seek Priorities for Pollution Clean-up".
Engineering News-Record 145, (15), 27 (1950)

33. Anon
"Coal Mining, Stream Pollution Culprit".
Engineering News-Record 145, 41-2 (1950)

34. Anon
"Washington Pollution Ban Opposed by Three Firms".
Engineering News-Record 144, (6), 24 (1950)

35. Anon
"Oregon Demands Paper Mill Clean-up as Stream Drive Accelerates".
Engineering News-Record 144, (5), 33 (1950)

36. Anon
"Pollution Control Process Faces Changes at Everett".
Engineering News-Record 144, (15), 28 (1950)

37. Anon
"Lagooning Suggested for Willamette Waste".
Engineering News-Record 144, (9), 33 (1950)

49. Cleary, Edward J.
"Interstate Commission Tackles Pollution Problem in Ohio River Valley".
Civl Engineering 20, (8), 32-34 (1950)

50. Congress
"Appropriation Act for Fiscal Year 1951 - P.L. 759, 81st Congress".
192 pp., approved Sept. 6, 1950

51. Cross, J. T.
Gallaher, W. U., Fillicky, J. G., and Hassler, J. W.
"Effects of Synthetic Detergent Pollution".
Jour. Amer. Water Works Assoc. 42, 17 (1950)

52. Fuller, R. B.
"Position of the Pebble Phosphate Industry of Florida in Stream Sanitation as of November 1949".
Proc. 5th Industrial Waste Conf., Purdue U., Engineering Bulletin #72 (1950)

53. Hedger, Harold E.
"Los Angeles Considers Reclaiming Sewage Water to Recharge Underground Basins".
Civil Engineering 20, (5), 39-40 (1950)

54. Kemp. H. A.
"Potomac Valley Conservancy District Takes the Offensive Against Pollution".
Civil Engineering 20, (1), 33-36, 86 (1950)

55. Krantz, H. H.
"Cincinnati Plans Pollution Drive".
Civil Engineering 20, (4), 40-41 (1950)

56. Laboon, John F.
"Industrial Wastes Disposal at Pittsburgh, Pa.".
This Journal 22, 549-53 (1950)

57. LeBosquet, M. Jr.
"Recently Enacted Federal Water Pollution Control Legislation".
This Journal 22, 239-44 (1950)

59. Maryland
"State of Maryland Water Pollution Control Commission".
"Second Annual Report, (1948)". Baltimore, Md., 124 pp.

60. Moses, H. E.
"Pennsylvania's Clean Streams Program".
Jour. Amer. Water Works Assoc. 42, 146 (1950)

61. Murdock, Harold R.
"Industrial Wastes, A Staff Feature".
Ind. and Eng. Chem. 42, 71A-75A (1950)

63. Public Health Service
"Suggested State Water Pollution Control Act and Explanatory Statement".
P.H.S., Div. of Water Pollution Control, Washington, 26 pp. (1950)

64. Rawn, A. M.
"Blending of Sewage Effluent with Natural Waters Permits Reuse".
Civil Engineering 20, (5), 40-41, 89 (1950)

66. Stillerman, Larry
"Financing Tangle Stalls Indiana Sewerage Work".
Engineering News-Record 145, 27-28 (1950)

68. Washington State Pollution Commission.
"Minimum Requirements for the Control of Industrial Wastes".
This Journal 22, 514-20 (1950)

69. Wright, C. T.
"Pollution of Irrigation on Waters".
This Journal 22, 1403-12 (1950)

Other references on stream pollution and abatement are as follows:

38. Anon
"Seek Federal Study of Stream Pollution".
Engineering News-Record 144 (9), 28 (1950)

39. Anon
"Public Health 1950".
"Conservation by Pollution Control".
Public Health Reports, 65, 49, 1640-41 (1950)

40. Anon
"Checkmate: Temporary or Permanent".
Engineering News-Record, 144, (17), 21 (1950)

41. Anon
"Budget Cuts for Construction Hit U.S. Work and Local Plans".
Engineering News-Record 145, (12), 23 (1950)

42. Anon
"Budget Bureau Money Cuts Hit Heaviest at Construction".
Engineering News-Record, 145, (16), 25 (1950)

43. Anon
"Perspective - How to Get Pollution Abated".
Engineering News-Record 144, (14), 112 (1950)

44. Anon
"Paper-Mill Pollution".
Engineering News-Record 145, (22), 17 (1950)

45. Anon
"Kentucky Initiates Water Pollution Control Program".
Civil Engineering 20, (9), 60 (1950)

46. Anon
"Seek Clean Stream Law".
Engineering News-Record 144, (6), 26 (1950)

47. Anon
"Water Pollution Legislation".
Chemical Age. (London), 61, 835 (1949)
Abstract, p. 721

48. Black, Hayes H.
"Federal Industrial Pollution Studies".
This Journal 22, 1049-53 (1950)

58. MacKenzie, V. G.
"United States Public Health Service Program in Industrial Waste Research".
Proc. 5th Industrial Waste Conf., Purdue U., Engineering Bulletin #72, 7-14 (1950)

62. Oosterle, F. D.
"New Pumping and Piping System for Industrial Waste Eliminated Pollution of River".
Heating, Piping and Air Conditioning 20, 100-1 (1950)

65. Schwob, C. E.
"The 1948 Federal Stream Pollution Control Law".
Proc. 4th Industrial Waste Conf., Purdue U.
Engineering Extn. Ser. No. 68, 15-19 (1948)

67. Tyler, T. G.
"Disposal of Sewage into Tidal Waters".
Sew. and Ind. Wastes 22, (5), 636 (1950)

Bacteriology

Wolman[14] discussed the diversity of standards which exist for stream quality solely from a bacterial content. It was pointed out that the application of standards of fresh waters to sea water must be critically observed and questioned. Consideration must be given to the economic factors involved in the community in the use of judgment standards.

Vaccaro et al[10] carried out laboratory experiments to determine why E. coli was unable to survive in sea water. After study of seasonal effects and methods of sterilization, the author suggests that the bactericidal action of sea water may be due to an antibiotic action of the natural marine flora.

Williams[13] has shown that 127 of 365 coliform strains studied were able to produce demonstrable amounts of phenol when grown in casein digest medium. One hundred and twenty-three of the strains were citrate negative Escherichia and four were aerobacter.

Lieb[6] concluded from his studies that phenol decomposing bacteria at 22°C. were present in the mud of river banks but not in the water.

Colmer et al[2] have repeatedly isolated from acid mine drainage a bacterium closely resembling those

displayed by the genus Thiobacillus. The bacterium rapidly oxidized the ferrous iron of such drainage to the ferric state, however, the mechanism responsible for the oxidation in either natural or artificial acid mine waters was not determined.

Hart (4) found that bacterial count was not a good indicator of industrial pollution, nor was any single organism of value.

Gray (3) has described a motile rod-shaped organism which on nitrogen-free media fixed appreciable quantities of nitrogen gas. The bacterium was isolated in pure culture from three chalk streams near Cambridge, England. Growth was promoted by sugars, and nitrate was rapidly reduced.

Vaughn (11) reported that the growth and development of turbidity in Koser's citrate medium by E. coli, E. acidilacti, E. communior, and E. neapolitana was dependent on certain supplementary compounds such as acetate, lactate, propionate, glucose, fructose, l-asparagine and glutamic acid. The citrate in Koser's medium was utilized when the concentration of the supplementary compounds reached 0.1 to 0.5 per cent.

Studies were made directly on river water by Viehl regarding the bacterial relationship and the complexities

involved in the natural purification. In winter more bacteria were present in the river water than in summer, thus tending to balance the lowered activity. The effect of temperature on the rate of organic decomposition in river water and sewage was therefore less than would be expected.

Chambers (1) attempted to determine the number of coliform bacteria necessary for visible gas production in lactose-containing broth. Results from 780 determinations indicated a range of coliform population from 40 to 300 million per ml. with an arithmetic mean and median about 170 million per ml. Production of a small bubble most frequently required at least 75 million organisms. Gas production in lactose was obtained with 40 per cent lower population than in two per cent B.G.B. broth.

Promer et al (8) described a method for enumeration of tubercle bacilli, consisting of heating the sample at 50°C. for 30 minutes, and cultivating on Dubo's agar to which five units/ml. of penicillin and 50 units/ml. of grisein have been added. Application of this method in the laboratory and in a preliminary plant survey indicated the following treatments effective for removal

of tuberculosis organisms:

1. Coagulation with $FeCl_3$, followed by settling,
2. Continuous filtration through sand at a 0.24 m.g.a.d. rate and
3. Chlorination to a residual of at least 0.5 p.p.m. free chlorine.

Kruse[5] described a simplified technique to determine the presence of E. coli in drinking water. Varying quantities of water were drawn through membrane filters, which were cultured at 46°C. and 41°C. E. coli of human or warm blooded animal origin will grow at both temperatures, while those from cold blooded animals will not grow at 46°C. and were markedly inhibited at 41°C.

Mueller[7] established a quick test for coli determinations in fecally polluted drinking water by use of the membrane filter technique combined with a test for indol formation in tryptose broth. A positive result could be read after three to eight hours and the presence of E. coli demonstrated.

The work of Sears[9] on the persistence of E. coli strains in the human intestinal tract, recorded information which may be of use in anticipating the organisms to be found in streams receiving pollution from such sources.

References

1. Chambers, Cecil W.
"Relationship of Coliform Bacteria to Gas Production in Media Containing Lactose".
Public Health Reports 65, 619-27 (1950)

2. Colmer, Arthur R., Temple, Kenneth L. and Hinkle, Melvin E.
"An Iron Oxidizing Bacterium from the Acid Drainage of Some Bituminous Coal Mines".
Jour. Bact. 59, 317-28 (1950)

3. Gray, E. and Smith, J. D.
"A New Aquatic Nitrogen-Fixing Bacterium from Three Cambridgeshire Chalk Streams".
Jour. of General Microbiology 4, 281-5 (1950)

4. Hart, W. B.
"Use of Bacteria Studied as a Measure of Stream Pollution by Wastes".
Pet. Processing 5, 498 (1950), Abst. This Journal 22, 1255-56 (1950)

5. Kruse, H.
"The Technique Used at the Hygiene Institute of the University of Goettingen for the Demonstration of E. Coli in Drinking Water by Means of the Membrane Filters.
Zentr. Bact. I. Abt. Orig. 153 (6/7), 241-8 (1949)

6. Liev, F.
"The Biology of Phenol Decomposing Organisms".
Gas Wasser Warme, 3, 101-7 (1949)

7. Mueller, G.
"The Rapid Determination of E. Coli in Fecally Contaminated Drinking Water".
Zentralbl. Bakt. I Abt. Orig. 153 (6/7), 237-40 (1950)

8. Promer, D., Heukelekian, H., Rogotskie, R. A.
"Survival of Tubercle Bacilli in Various Sewage Treatment Processes. I. Development of a Method for the Quantitative Recovery of Mycobacteria from Sewage".
Public Health Reports 65, 851-9 (1950)

9. Sears, H. J., Brownlee, Inez and Uchiyama, John K.
"Persistence of Individual Strains of E. Coli".
Jour. Bact. 59, 293-301 (1950)

10. Vaccaro, R., Briggs, M., Carey, C. and Ketchum, B.
"Viability of E. Coli in Sea Water".
Am. Jour. Pub. Health 40, 1257-66 (1950)

11. Vaughn, Reese H., Osborne, Joel T., Weddus, George T., Tabachnich, Joseph, Beisel, Gordon, C. and Braxton, Thelma
"The Utilization of Citrate by E. Coli".
Jour. Bact. 60, 119-27 (1950)

12. Viehl, K.
"Effect of Temperature on the Self Purification of Streams with Special Reference to the Bacteriological Changes".
Zeitsch. Hyg. Infektionskrankheiten 122, 81 (1939)

13. Williams, O. B. and English, Jack D.
"Phenol Production by Coliform Bacteria".
Jour. Bact. 60, 101-2 (1950)

14. Wolman, A.
"Bacterial Standards for Natural Waters".
This Journal 22, 346-52 (1950)

Biology

Patrick (43, 44) believes that a great many species of the various aquatic plants and animals are present in healthy streams but no single group is represented by a great number of individuals. A moderately toxic pollutant would result in a reduction of the number of species in the stream and a greater abundance of the individuals of the remaining tolerant species because of the decrease in biological competition. Very toxic wastes kill all organisms. In only a few cases, however, were species found that only occurred under a given degree of pollution and could thus be truly regarded as pollution indicators.

Biological measures of stream quality are useful for several reasons:

1. The physiological activities of aquatic organisms are essential to the maintenance of healthy water conditions, therefore, direct measurement of biological life indicates the quality of the stream.
2. Chemical and physical characteristics of healthy streams vary widely and can not be reduced to simple standards. No means are available for testing all toxic agents.

3. Attached organisms of the stream reflect conditions over extended periods of time while chemical and physical data from water samples indicate only conditions at the moment taken.

Van Horn[58] stated that both field and laboratory studies are necessary to evaluate biological indices of stream pollution. Bottom living plants and animals, as well as the fish and plankton are useful indicators of the degree and type of pollution. Laboratory bio-assays with fish and Daphnia aid in the studies of toxic industrial wastes. Abatement of pollution in the final analysis must be evaluated and confirmed by the biologist.

Two valuable reviews on the toxicity of various substances to aquatic life were prepared by Doudoroff and Katz[17] and by Rudolfs, et al[48]. Doudoroff and Katz reviewed the literature on the toxic effects of alkalies, acids, carbon dioxide, carbon monoxide, chlorine, chloramines, cyanogen chloride, hydrogen sulfide, sulfur dioxide and abnormally high oxygen tension to fishes. Rudolfs et al[48] reviewed the literature on the effects of toxic materials on the microflora and microfauna of streams. The effects of enriching

materials which cause the eutrophication of lakes is discussed. Certain undesirable plankton forms become more abundant in eutrophic bodies of water and the more desirable forms disappear.

The cause of a fish kill in waters containing ferro- and ferricyanides at concentrations far below those generally accepted as non-lethal was shown by Burdick and Lipscheutz[10] to be due to decomposition and release of the cyanide ion from these substances. Experimental data places the toxic level of these compounds under similar levels of light intensity at a concentration between 1 and 2 p.p.m. Rapid development of toxicity has been demonstrated at a concentration of 2 p.p.m. of either potassium ferro- or ferricyanide.

Milne[37] believes that bio-assay of cyanide wastes in strongly aerated aquaria often gives misleading results. When bio-assays of cyanide solutions are carried on in waters of a high bicarbonate content, a buffered solution in the neutral pH zone results. Free HCN and some cyanide ion are formed and, therefore, HCN and not merely the cyanide ion is being tested. Continuous aeration results in the constant loss of HCN and a continued hydrolysis of the remaining cyanide solution. In bio-assays, replacement of the lost acid should be standard procedure in order

to yield valid results.

Milne (33) found that goldfish were not harmed in a solution of nickelocyanide prepared by adding nickel sulfate to a solution of sodium cyanide. The nickelocyanide complex could easily be dissociated by strong acids in HCN and hence should not be discharged into extremely acid waters. It can also be decomposed by chlorine to give toxic cyanogen chloride.

Corcoran (15) stated that 49 per cent of fish kills by industrial wastes during a three-year period in Michigan was attributed to cyanide. It appears that as little as 0.1 p.p.m. Cn is generally fatal to fish.

Brockway (6) believes that the ammonia content of waters in fish cultural establishments should be controlled. As the ammonia content of the water rises, the fish lose their ability to use oxygen. At 1 p.p.m. ammonia, the oxygen content of the fish blood decreases to about one-seventh its normal value and the carbon dioxide increases to about 15 per cent.

Castillon and Altschul (12) combined gossypol with proteins, amino acids and carbohydrates. Gossypol itself was non-toxic to goldfish, but the water soluble products of the combination was toxic in concentrations of 1/100,000. The separated pigment glands of cottonseed were significantly less toxic to fish than were the

gossypol combination products.

Experiments with fish by Minkina[39] showed a concentration of Fe of more than 0.2 p.p.m. and of Al exceeding 0.5 p.p.m. are lethal to fish. On the other hand, a concentration of Fe of 0.1 p.p.m. or of Al of 0.25 p.p.m. stimulates growth. Small amounts of Fe, 0.1 p.p.m., in a medium of pH 6 inhibits growth while Fe of 0.01 p.p.m. in a pH of 7.5 stimulates fish growth.

Erichsen and Naemerrer[18] reported a fish and plankton kill by $Fe(OH)_3$. Brown coal sludge adsorbed the $Fe(OH)_3$ so that the water was no longer toxic to fish. Fuller[21] found that top minnows and bream are not killed in waters taken from settling basins used to remove the semi-colloidal wastes resulting from the pebble phosphate mining operations. Flotation chemicals particularly tall oil in heavy concentrations are lethal to fish and should not be poured directly into the stream. Effluents from the silting basins are non-toxic.

Brown and Kurtis[8] reported that spent caustic soda solutions from petroleum refineries containing phenolic substances and sulfides are toxic to fish and also have a high oxygen demand.

Trinitrotoluene was found by Seifert[49] to be toxic to fish at a concentration of 2.0 mg/l and hexa nitrodiphenylamine is toxic at 0.15 mg/l.

A heavy fish kill reported by Sorenson[51] was traced to waste water from a laundry. There was no significant oxygen depletion and the fish kill was believed to be due to toxicants used in chemical cleaning or to some poisonous substances washed out of the clothes. Microfauna especially rotifers were also killed but the microflora were not markedly affected.

Sewage pollution was found by Connell and Cross[14] to favor the growth of Gonyaulax in Offat Bayou near Galveston. Fish kills follow the occurrence of the red water organism. High B.O.D. and consequent anaerobic conditions were attributable to the Gonyaulax bloom and were important contributing causes to the mass mortality in this region.

It has been suggested that the pebble phosphate industry effluent has added to the phosphate content of the sea water thus contributing to the growth of the red tide organisms. Fuller[21] states that these discharges are not great enough to raise the phosphate content in the large areas of the sea in which the red tide was observed.

Cross[16] found that raw sewage had apparently benefited the fish of Stillwater Creek, Oklahoma, for the abundance of fish is now greater than found in previous surveys. Sludge deposition in the stream bed, however, has increased. Some of the increase in fish production may be due, however, to the regulation of stream flow because of the presence of impoundment reservoirs.

Fish and Rucker[19] found that the B.O.D. load of the Williamette and its tributaries reduces the dissolved oxygen of this river to create a pollutional barrier to important salmon runs. Laythe[31] states that the acute pollution of the river has eliminated the important summer runs into this river. Removal of this pollutional barrier would increase the valuable salmon run in the Williamette to five times its present size.

Liebmann[32] reported that wastes from the wood sugar industry contain furfural, resins, tannin, acids and sometimes soda, $Ca(OH)_2$, ammonium fluoride and disinfectants. Wastes were fairly toxic to fish and had a high oxygen demand. Sludge banks are deposited and growth of Sphaerotilus is encouraged.

Lawrence[30] determined the toxic concentration of the commercial insecticides, D.D.T., methoxychlor, toxaphene, chlordane and B.H.C. to commond food fish in aquaria and earthern ponds. Pagan and Hageman[41] used guppies to test for the D.D.T. residues on agricultural products.

Tarzwell[57] studied the effect of fishes and other aquatic life of the routine manual and airplane application of D.D.T., D.D.D., Chlordane and toxaphene. Many crustacea were more sensitive than fish. The solvent, type of water, pond vegetation, silt or turbidity all effect the toxicity of D.D.T. to fish. Fish were found to vary in their sensitivity to D.D.T.

A major fish kill due to chlordane was reported near Waterloo, Iowa by Morgan[40]. This insecticide, which experiments showed to be toxic at 0.5 p.p.m., was accidently poured into the city sewers and killed fish in the receiving stream.

Addison[1] reported that an accidental discharge of toxic substances from an antiseptic manufacturing plant caused a heavy fish kill. Chemical and biological examination of another lake showed fish were destroyed as a result of highly alkaline conditions combined with excess oxygen in the water.

Van Horn, Anderson and Katz[59] showed by bio-assay methods that the sulfides, mercaptans, resin acid soaps and sodium hydroxide in kraft pulp mill wastes are most toxic to fish, crustacea, and aquatic insects. Under efficient operation, the loss of these compounds to the receiving stream can be restricted to non-toxic levels.

Hasler and Wisby[23] showed that minnows under laboratory conditions could be trained to detect phenols in concentrations as low as 1/2 p.p.b. They also could be trained to distinguish between phenol, o- and p-chlorophenol.

MacKenzie[36] reported that studies by the Biology Section of the Environmental Health Center, Public Health Service, are being directed to the development of standardized techniques for routine bio-assays of industrial wastes that are troublesome because of volatility and high oxygen demand.

Daphnia are sensitive to the same toxicants as fish according to Reimann[45]. Substances that kill Daphnia in twenty-four hours or less are also toxic to fish. The author suggests Daphnia as a substitute for fish in bio-assay procedures.

Anderson (2) determined the apparent threshold concentrations of toxicity to Daphnia of 25 cations. They found in general that Daphnia and related forms are more sensitive to cations than are fish. Copper, silver, mercury and cadmium were found to be among the more toxic cations.

Hunter (29) subjected Marinogammarus to various doses of mercuric chloride or copper sulfate and measured the toxicity by changes in the animal's activity. Copper interferes with the respiration and the osmo-regulatory system while mercury acts by direct and general poisoning of the protoplasm.

Chamberlain (13) surveyed the literature on the growth, occurrence and control of algae in water supplies, lists the algal groups known to produce tastes and odors and investigated the role of algae in the percipitation of calcium and magnesium salts in relation to their effect on water filtration. The Myxophyceae and Diatomales are the principal taste and odor producers.

Rodhe (46) made an extensive and thorough study of the environmental requirements of fresh-water plankton algae. Among the subjects studied were the determination of growth and chlorophyll content in pure cultures of plankton algae,

photometric determinations of iron concentrations in synthetic solutions and lake water, the source of iron in nutrient solutions, a nutrient solution for autotrophic plankton algae, phosphate as a growth factor, the influence of nitrate deficiency on growth and chlorophyll formation, iron as a limiting factor for growth, influence of magnesium and potassium deficiency on algae growth and temperature, and light as factors for the growth and annual periodicity of plankton algae.

Butcher (11) reported that even in unpolluted streams algae present at the source of a stream are replaced by a different biological community downstream because of the progressive increase of mineral salts due to natural drainage. In grossly polluted streams large numbers of Stigeoclonium first develop; this is then replaced by Nitzchia and Gomphonema. Finally the Cocconeis-Chaemisophon community develops.

Spencer's (52) six month study of a Massachusetts reservoir correlated the numbers of phytoplankton with dissolved oxygen, carbon dioxide, water temperature, sunlight, pH, soluble silicates, and the manganese content of the water. Water temperatures and hours of sunlight affected the abundance of some forms but did not account for the major pulses. Plankton pulses were accompanied

by an increase in dissolved oxygen, pH and by a decrease in free CO_2. Silica was considered a limiting factor in the production of Bacillariophyceae but did not affect the other classes. Manganese was absent from the epilimnion at all times.

A year long study of the ecology and annual changes of the plankton in the River Hooghly was made by Roy (47). Variations in the numbers of phytoplankton, particularly diatoms are responsible for annual variation in the yield of plankton.

Fjeringstad (20) made a study of the microflora of the River Molleaa and related the benthoalgae forms with pollution.

Stone and Abbott (53) found that sewage placed in troughs develops a green growth that does not settle out. Green organisms replace the original suspended solids. Their respiratory synthesis results in an increase in B.O.D. Authors developed a method of evaluating photosynthetic factor of samples by determining the dissolved oxygen of samples incubated in the dark and exposed to light.

Lord (33) reports that the modern activated sludge plant at Madison, Wisconsin, produces an excellent effluent which is high in inorganic nitrogen and

phosphates. The receiving lakes are enriched thereby resulting in excess algal blooms which in time decay, causing a pronounced odor nuisance.

Heusden[24] reports that the water supply of Amsterdam is heavily polluted and is allowed to self-purify by retention for 30 days in flow-through reservoirs. High concentration of nutrients results in blooms. From 0.12 to 0.25 mg ferric chloride per liter and 30 - 60 mg aluminum sulfate per liter adsorb the phosphate on the floc of the ferric and aluminum hydroxides. Plankton extracted the nitrates completely and to a large extent the phosphates from the water.

Buffle[9] discusses the effect of plankton in lake water in relation to its use as a source of supply and describes processes for the removal of plankton by sedimentation, chemical treatment, exposure to light and filtration.

Lovett and Brown[34] reported a fish kill during the nights of July 30 and July 31. This shallow lake had had a profuse growth of algae which caused an oxygen supersaturation and a pH of 9.5 - 9.6 in the water. These authors feel that the fish were killed by either the development of a high caustic alkalinity or the effects of supersaturation of oxygen or a combination of both.

Brown[7] found that in a lake of hard water and an initial pH of 8.1, Vaucheria, Spirogyra and Zygnema were killed by 10 p.p.m. copper sulfate. Elodea, Hippuris, Myriophyllium and Utricularia were unaffected by this dosage. From 6 to 10 p.p.m. of sodium arsenite destroyed all of the higher plants except Utricularia but stimulated algae and fungi. At this concentration, arsenic was not toxic to fish and tadpoles.

Only Peridinium and Diaptomus which were in the upper oxygenated layer of a lake were found by Atkin[3] to cause trouble by clogging filters. In the oxygen depleted lower layer blue-green algae have developed abundantly. A heavy rainfall causing an influx of cold water into reservoirs forced the layer containing Oscillatoria to the surface, resulting in a marked increase in color and taste of water.

Swartz[56] describes a method of enumeration of algae and discusses some taste and odor effects of certain algae. A chart is presented showing common algae found in water supplies.

Silvey et al[50] reviews the relationships of actinomycetes to taste and odor in water supplies and recommends methods of control and treatment of odors.

The actinomycete, Streptomyces, is believed to be the cause of objectionable tastes and odors in Southwestern water supplies instead of algae.

Surber and Everhart (55) used three applications of nigrosine to control a young growth of Chara in a pond. No bloom developed in this pond, whose water remained black for some time. No deleterious effects to bass and sunfish at the concentrations of nigrosine required for weed control were observed. The dye reduced the numbers of zooplankton but the bottom animals increased in number.

Mackenthun (35) reviews aquatic weed control in Wisconsin. In 1949, 33 lakes were treated with sodium arsenite. From five to ten p.p.m. sodium arsenite controls weeds in various situations without harm to fish life.

Hart (22) states that biological surveys not only indicate present conditions in the stream but also the past pollutional history. A research project established to determine the effectiveness of bacteria as a pollution index found that bacteria were not a suitable index since representative forms were found in both polluted and unpolluted streams.

Higgins[25] states that the disposal of radioactive wastes into streams exposes many aquatic organisms to a long continued low-level exposure of radiation. To study the effects of these wastes a tributary of the Clinch River, Tennessee, drainage which has been receiving radioactive wastes and which contains an apparently normal biota was selected for extended biological studies.

Bidwell and Kelly[5] report Salmonella originating from duck farms near the eastern end of Long Island were polluting oyster beds. These pathogens were found in the oysters and the areas polluted by these duck farms are, therefore, unsatisfactory for shell fish culture.

References

1. Addison, W.
"82nd Annual Report on the Salmon-Trout and Fresh-Water Fisheries in Yorkshire".
Yorkshire Fishery District, York, 19-36 (1949)

2. Anderson, B. G.
"The Apparent Threshold of Toxicity to Daphnia magna for Chlorides of Various Metals when Added to Lake Erie Water".
Trans. American Fisheries Society, 78 (for 1948) 96-113 (1950)

3. Atkin, D. J.,
"Plankton Variation in a Tropical Lake and Their Effect on Water Treatment".
Colonial Microbiological Res. Inst., Port of Spain, Trinidad, Repts. of Papers Read at Opening of Inst., 30-33 (1948)

4. Baines, S., and Finlayson, L. H.
"Record of an Ichneumon Attacking Spa thiophora (Dipt. Corydyluridae) in Sewage Filter Beds".
Ent. Mon. Mag. 85: 150-51 (1949)

5. Bidwell, M. H., and Kelly, C. G.
"Ducks and Shellfish Sanitation".
Am. J. Publ. Health, 40, 923-28 (1950)

6. Brockway, D. R.
"Metabolic Products and Their Effects",
The Progressive Fish Culturist 12, 126-30 (1950)

7. Brown, F. M.
"Askern Lake"
Naturalist, London, No. 828, 22-23 (1949)

8. Brown, K. M., and Kurtis, S.
"Difficult Waste Disposal Problem Solved".
Petr. Ref. 29, III, (1950). Also, Sewage and Ind. Wastes 22, 1507-08 (1950)

9. Buffle, J. P.
"Removal of Lake Plankton by Rapid Filters of a New Type".
Tech. sanit. Munic. 43, 106-19 (1948)

10. Burdick, E. G. and Lipschuetz, M.
"Toxicity of Ferro-and Ferricyanide Solutions to Fish, and Determination of the Cause of Mortality".
Transactions of the American Fisheries Society (for 1948), 78, 192-202 (1950)

11. Butcher, R. W.
"Pollution and Repurification as Indicated by Algae".
Proc. 4th Congress Inter. Microbiol. 1947, 449-50 (1949)

12. Castillon, L. E. and Altschul, A. M.
"Preparation of Water-Soluble Combination Products of Gossypol and Their Toxicity to Aquarium Fish".
Proc. Soc. Exptl. Biol. Med. 74, 623-26 (1950)

13. Chamberlain, W. J.
"The Effects of Algae on Water Supply".
Univ. Queensland Papers, Dept. Chem. 1, No. 29, 80 pp. (1948). C.A. 44, 8568 (1950)

14. Connell, C. H. and Cross, J. B.
"Mass Mortality of Fish Associated with the Protozoan Gonyaulax in the Gulf of Mexico".
Science 112, (2909), 359-63 (1950)

15. Corcoran, A. N.
"Treatment of Cyanide Wastes from the Electroplating Industry".
This Journal 22, 228-38 (1950)

16. Cross, F. B.
"Effects of Sewage and of a Headwaters Impondment on the Fishes of Stillwater Creek in Payne County, Oklahoma".
The American Midland Naturalist 43, 128-45 (1950)

17. Doudoroff, P. and Katz, M.
"Critical Review of Literature on the Toxicity of Industrial Wastes and Their Components to Fish. I Alkalies, Acids and Inorganic Gases".
This Journal 22, 1432-58 (1950)

18. Erichsen, L. V. and Naemmerer, K.
"The Effect of Mine Drainage Water Containing Metallic Salts on Biological Relations of a River System".
Gas u. Wasserfach 91, 16-18 (1950)

19. Fish, F. F. and Rucker, R. R.
"Pollution in the Lower Columbia Basin in 1948 with Particular Reference to the Williamette Basin".
Special Scientific Report Fisheries No. 30, 22 pp.
U. S. Fish and Wildlife Service, Washington, D. C.
(1950)

20. Fjeringstad, E.
"No. 5, Microflora of the River Molleaa with Special Reference to the Relation of the Benthoalgae to Pollution".
Folia Limnologica Scandinaoica, Copenhagen (1950)

21. Fuller, R. B.
"The Position of the Pebble Phosphate Industry of Florida in Stream Sanitation as of November 1949".
Proc. 5th Ind. Waste Conf., Purdue U., 366-71 (1950)

22. Hart. W. B.
"Use of Bacteria as Measure of Stream Pollution by Wastes".
Pet. Processing 5, 498 (1950). Also, This Journal, 22, (9), 1255-56 (1950)

23. Hasler, A. D. and Wisby, W. J.
"Use of Fish for Olfactory Assay of Pollutants (Phenols) in Water",
Trans. Am. Fisheries Society, 79 (for 1949), 64-70 (1950)

24. Heusden, G. H. P.
"The Combating of Plankton in Flow-through Reservoirs".
Water, Den Haag, 31, 197,202,207-210 (1947)

25. Higgins, E.
"Radioactive Wastes and Their Significance in Stream Ecology".
Trans. Amer. Fisheries Society, 79 (for 1949), 217-32 (1950)

26. Horosawa, I.
"Biological Studies on Activated Sludge in the Purification of Sewage. I. Studies on the Structure of Biotic Communities in Activated Sludge".
J. Waterworks and Sewerage Assoc. (Japan) No. 178, 2, (1949). Also This Journal, 22 (7), 959 (1950)

27. Horosawa, I.
"Biological Studies on Activated Sludge in the Purification of Sewage. II. Characteristics of Activated Sludge Biota and Its Ecological Classification".
J. Waterworks and Sewerage Assoc. (Japan), No. 181, 8, (1949). Also, This Journal 22, (7), 959 (1950)

28. Horosawa, I.
"Experimental Studies on the Utilization of Copper Mine Stones As Trickling Filter Media".
J. Water Works and Sewerage Assoc. (Japan), No. 171, 15 (1949). Also, This Journal 22, (7), 959 (1950)

Chemistry

Members of the Research Committee, Federal Sewage Works Association Subcommittee on Toxicity, Section I, presented a comprehensive review of the effects of many industrial wastes and components thereof on anaerobic and aerobic processes, natural purification rates, stream micro-flora and micro-fauna and on the B.O.D. test (15).

Velz (18) discussed some of the factors which must be considered in securing samples to be used as a basis for calculation of the conditions of receiving waters under varied conditions. In discussing Velz's paper, Clark (1) enumerated some of the T.V.A. sampling techniques, such as following a given mass of water down stream, and emphasized the necessity for the consideration of all phases of the problem in setting up sampling programs. Hyde (6) described the construction of a depth sampler from a commercial pressure cooker.

Lawrance (8) reported on the application of sodium nitrate for control of nuisance conditions in the Androscoggin River. Winkler and Wipf (19) stated that sodium nitrate was more satisfactory than sodium chloride in chemically tracing the flow of water.

There were a number of papers on the borderline where the interests of water plant operators meet those of people concerned with stream pollution. Cross et al.[2] discussed the effects of pollution by synthetic detergents upon the production of a satisfactory drinking water. Schaafsma[16] studied the effect of organic materials in swamp water on the coagulation processes used in the production of a satisfactory drinking water. Rohlich and Sarles[14] considered the chemistry of organic compounds responsible for tastes and odors. Muehlberger[11] reviewed the hazards resulting from chemical contamination as related to water supply.

Contamination by particular chemical compounds was considered in two papers. Ettinger and Ruchhoft[3] studied the persistence of mono-chlorophenol in polluted river water and sewage dilutions. Lyne and McLachlon[9], investigating the persistence of ground water contamination by trichloroethylene, noted the toxicity of this chemical, and presented a method for its determination.

Tyler[17] and Gould[4] considered factors in the disposal of sewage into tidal flows. The pattern of dilution, retention and stratification is important and Tyler goes into detail regarding techniques used in

studying this factor. Horton[5] reported an intensive survey of the Wabash River, designed to measure the self-purification capacity of that stream. Petru[12] discussed the overloading of sections of the Elbe and Vetava Rivers by industrial effluents.

Matsubara[10] described laboratory experiments designed to evaluate the relationship of such physico-chemical parameters as depth, temperature and flow velocity with self purification. Kalabina et al.[7] studied the effect of toxic substances in effluents from non-ferrous metal industries on microorganisms and biochemical processes associated with self-purification of water in storage basins. Porter and Bishop[13] described the use of oxidation ponds for the purification of paper mill wastes (ground wood and bleached or unbleached kraft wastes). The ponds afford thirteen days storage. The initial B.O.D. of 200-230 p.p.m. is reduced to 35 to 90 p.p.m. The greatest purification is obtained during the summer months, corresponding to minimum flows in the receiving stream.

References

1. Clark, Robert N.
Discussion of Velz's paper on "Sampling for Effective Evaluation of Stream Pollution".
This Journal 22, 683-84 (1950)

2. Cross, J. T., Gallaher, W. V., Filicky, J. G., and Hassler, J. W.
"Effects of Synthetic Detergent Pollution".
J. Am. Water Works Assn. 42, 17 (1950)

3. Ettinger, M. B. and Ruchhoft, C. C.
"Persistence of Chlorophenols in Polluted River Water and Sewage Dilutions".
This Journal 22, 1214 (1950)

4. Gould, Richard H.
Discussion of Tyler's paper on "Disposal of Sewage into Tidal Waters".
This Journal 22, 696-98 (1950)

5. Horton, Robert K.
"Pollution Capacity Studies of the Wabash River".
Proc. of 5th Ind. Waste Conf. Purdue U., 330-37 (1949)

6. Hyde, A. C.
"Pressure Cooker Sampler".
This Journal 22, 1068 (1950)

7. Kalabina, M. M., Viss, K. A. M., Razumov, A. S. and Rogovskaja, T. J.
"Effect of Toxic Substances in Effluents from Non-Ferrous Metal Industries on Microorganisms and Biochemical Process Associated with Self Purification of Water in Storage Basins".
Gigiena 9, No. 10/11, 1 (1949)
Brit. Abs., B-III, 66 (1950)

8. Lawrance, W. A.
"The Addition of Sodium Nitrate to the Androscoggin River".
This Journal 22, 820 (1950)

9. Lyne, F. A. and McLachlon T. A.
"Contamination of Water by Trichloroethylene".
Analyst 74, 513 (1949)

10. Matsubara, T.
"Hygienic Studies on the Self Purification of River Waters".
Mitt. Med. Akad. Kioto, 28, 1005-40 (1940)

11. Muehlberger, C. W.
"Possible Hazards from Chemical Contamination in Water Supplies".
J. Am. Water Works Assn. 42, 1027 (1950)

12. Petru, A.
"Purity of River Water".
Paliva a Voda 29, 344-48 (1949)
Brit. Abs., B-III, 158 (1950)

13. Porter, C. C. and Bishop, Fred W.
"Treatment of Paper Mill Waste in Biochemical Oxidation Ponds".
Ind. Eng. Chem. 42, 102-06 (1950)

14. Rohlich, G. A. and Sarles, W. B.
"The Chemistry of Organic Compounds Responsible for Tastes and Odors".
Taste and Odor Control J. 15, 1-12 (1949)

15. Rudolfs et al.
"Review of Literature on Toxic Materials Affecting Sewage Treatment Processes, Streams, and B.O.D. Determinations".
This Journal 22, 1157-91 (1950)

16. Schaafsma, N. D. R.
"The Removal of Organic Materials from Surface Water, Particularly from Swamp Water in Netherlands, India".
Dolft (Neth.), 124 (1947) J. Am. Water Works Assn. 42, 50 (1950)

17. Tyler, Richard G.
"Disposal of Sewage into Tidal Waters".
This Journal 22, 685-96 (1950)

18. Velz, C. J.
"Sampling for Effective Evaluation of Stream Pollution".
This Journal 22, 666-82 (1950)

19. Winkler, G. and Wipf, M. H.
"Water Measurements by Chemical Methods".
Schweiz, Bauztg. 65, 417-19 (1947)

Oxygen Sag and Self Purification

The calculations involved in fitting B.O.D. data to the unimolecular equation, have been the subject of several papers. Thomas[4] presented a simple method of making a graphical approximation of the "K" and "L" in the equation $Y - L(1-10^{-Kt})$. Later, Moore et al.[2] presented a method which gives somewhat better accuracy than the method discussed above, and yet requires only relatively simple calculations. The calculation technique may be modified to compute the lag. In discussing this paper, Ruchhoft[3] pointed out the desirability and limitations of the unimolecular equation, and listed some current studies which may lead to an improved knowledge of biological oxidation.

LeBosquet and Tsivoglou[1] presented a method for making practical calculations in terms of stream loading in connection with oxygen sags. The method uses the dissolved oxygen profile of the stream in connection with the Streeter-Phelps equations as a basis for the calculations, but avoids assumption of oxidation or reaeration constants.

References

1. LeBosquet, M., Jr. and Tsivoglou, E. C.
"Simplified Dissolved Oxygen Computations".
This Journal 22, 1054-61 (1950)

2. Moore, Edward W., Thomas, Harold A. and Snow, William Brewster
"Simplified Method for Analysis of B.O.D. Data".
This Journal 22, 1343-54 (1950)

3. Ruchhoft, C. C.
Discussion of Paper by Moore et al. on
"Simplified Method for Analysis of B.O.D. Data".
This Journal 22, 1353-55 (1950)

4. Thomas, Harold A., Jr.
"Graphical Determination of B.O.D. Curve Constants".
Water and Sewage Works 97, 123-24 (1950)

Stream Standards

The trend toward stream zoning and the setting of water quality criteria based on particular water uses has been further exemplified. In discussing stream quality objectives, LeBosquet[1] stresses that the degree of pollution abatement depends on stream uses with due regard to the rights of public and riparian owners. Public Law 845 gives the primary responsibility to the States for setting objectives. The word "objective" denoting a desirable ultimate is preferred over the word "standard" which implies something fixed and to be reached soon. In setting objectives, it is necessary to provide for normal low stream flows, the proper mixing of effluents, and proper sampling where settling solids or floating substances are objectionable. Examples of stream objectives are given including those of the International Joint Commission, the Ohio River Sanitation Commission, the New York "Water Classification Standard System" and the Indiana Stream Control Board.

In England, the Rivers Pollution Subcommittee[2] has stated that stream standards are desirable and practicable. No standards have been fixed, however, pending

agreement on specific tests to be adopted for measurement of general stream properties.

The New York State Water Pollution Control Board[3] has devised a stream classification system based on the best usage for which a water-course is utilized and the water treatment methods needed to satisfactorily provide such usage. Water quality standards are specified for the various classifications of surface waters, tidal salt waters and underground waters. To illustrate this system, surface waters are classified into some seven categories based on water usage, e.g. Class AA used for drinking, culinary, or food processing purposes and Class F used for sewage and industrial waste disposal only. Specific quality standards have then been set for each of these categories.

Pollution control legislation in California has been described by Grayson[4]. Through legislation enacted in 1949, a State Pollution Control Board and nine regional boards were formed and assigned specific powers and duties. The state board has stated its policy on water quality criteria based on various water uses. Bacterial, chemical, and physical characteristics have been assigned specific limitations for each use cited.

The Interstate Commission on the Potomac River Basin[5] has established water quality standards for four stream classifications. Quality requirements are specified in terms of coliform content, color, turbidity, pH, dissolved oxygen, and other characteristics.

Rodger[6] discussed the radiation level considered safe for potable waters and also the monitoring system necessary for a water supply. Muehlberger[7] discussed the establishment of safe limits for toxic substances. Cadmium and hexavalent chromium toxicity limits were reviewed in detail. The Public Health Service standard of 0.05 p.p.m. hexavalent chromium seems amply safe whereas the exact toxic limit of cadmium is not sufficiently defined by present limited data.

References

1. LeBosquet, M.
"Stream Quality Objectives".
This Journal 22, 1459 (1950)

2. Anon
"Standards for Trade Effluents".
Chem. Trade Journ. (London) 125, 723 (1949)
Abstract, This Journal 22, 587-88 (1950)

3. Anon
New York State Water Pollution Control Board-
Classifications and Standards of Water Quality
and Purity
J. Am. Water Works Assoc. 42, 1137 (1950)

4. Grayson, L. W.
California Pollution Control Legislation
J. Am. Water Works Assoc. 42, 1133 (1950)

5. Anon
"Water Quality Criteria Set Up for Potomac River
Basin".
Sew. and Ind. Wastes Eng. 21, 540 & 554 (1950)

6. Rodger, W. A.
"Atomic Wastes and Water Quality".
J. Am. Water Works Assoc. 42, 533 (1950)

7. Muehlberger, C. W.
"Possible Hazards from Chemical Contamination in
Water Supplies".
J. Am. Water Works Assoc. 42, 1027 (1950)

Stream Surveys and Studies

Many comprehensive stream pollution survey programs have been reported. Interim reports are available for certain of the programs and final reports have been made available for others. Mostly, such reports have been printed as separate publications and have been abstracted in the various periodicals. Certain of this literature as well as other publications are of a general nature applicable to other survey work.

Mobile laboratory facilities are being more widely utilized for survey work. McDill[9] describes their use on a survey of the Miami River in Ohio. Laboratory analyses made and results of the survey are also reviewed. Sanderson[10] describes mobile operations for routine field examinations in New York State. Some of the problems of stream surveys are also outlined.

The Ohio River Valley Water Sanitation Commission has reported on its second year of activities in a proposed eight-year program[1]. General accomplishments regarding stream and industrial waste analyses and abatement objectives are described. Special projects undertaken by the Commission and specific municipal and industrial

developments regarding pollution abatement are discussed in detail. The Commission also reported an extensive survey recently conducted on the Ohio River[2]. This survey involved a two-week, 24 hour per day sampling schedule from 32 sampling points over a 900 mile length of the river. Water quality was determined at principal tributaries and major sources of pollution. To standardize laboratory techniques, state personnel were given special instruction at a seminar conducted by the Environmental Health Center in Cincinnati.

A comprehensive pollution report on the Clarion River in Pennsylvania has been prepared by Camp, Dresser, and McKee[7]. Significant industrial wastes discussed include wastes from wood distillation plants, pulp and paper mills, carbon plants, tanneries, and a brewery. The pulp and paper mills were found to be responsible for some 93 per cent of the total organic material discharged into the river. Criteria for establishing quality standards commensurate with water uses and the assimilation capacity of streams for carrying wastes are discussed. Abatement procedures are recommended together with cost estimates.

The Massachusetts Department of Public Health[3] has reported on its investigation of nuisance conditions on the shores and beaches at five cities along a 45 mile coastline of Massachusetts. Bacterial loadings, travel of sleek areas and existing sewer outfalls were studied. Enforcement of rules governing pollution of inland and tidal waters together with further investigations were recommended.

Pollution conditions along the Sudbury River in Massachusetts, were reported by the Sudbury Valley Commission[4]. Certain pollution controls were recommended such as zoning of land uses and diversion of sewage flow in view of the many uses of the river.

A water quality survey of the Hampton Roads, Virginia shellfish growing area has been reported[5]. Comparison with a 1934 survey indicates that the general water quality is better at the present time. A potential hazard in the area is the discharge of raw sewage from ships.

A condensation has been published[6] of the Interim Report to the International Joint Commission regarding pollution in the St. Clair River, Lake St. Clair, Detroit River, and St. Marys River. The boundary waters' investigation involved a survey of water quality conditions and

sources of pollution, the establishment of objectives for water quality in the area, and the cost estimates for both industrial and municipal waste treatment to meet those objectives.

Love[8] has reviewed the general chemical quality of both surface and ground waters in the Middle Atlantic States. Areas subject to pollution are briefly discussed with regard to type of pollution and possible remedial measures.

References

1. Anon
Ohio River Valley Water Sanitation Commission
2nd Annual Report (1950)

2. Anon
"Big Sampling Program for Ohio River".
Water and Sewage Works 97, 414 (1950)

3. Anon
Report of the Massachusetts Department of Public Health Relative to an Investigation and Study of the Cause Creating a Nuisance on the Shore and Beaches of Marblehead, Salem, Danvers, Beverly and Manchester and of Means of Rectifying Such Conditions.
Mass. House Doc. No. 2, 236, 14 (1949)
Abstract, This Journal 22, 1506 (1950)

4. Anon
Report of the Sudbury Valley Commission Relative to the Sudbury River and Its Environs.
Mass. House Document No. 2351, 142 (1950)
Abstract, This Journal 22, 1506-07 (1950)

5. Anon
Water Quality Survey of Hampton Roads Shellfish Areas (1949-50)
Virginia State Department of Health in Cooperation with U.S.P.H.S. (1950)

6. Anon
Interim Report to the International Joint Commission 12 (1949)
J. Am. Water Works Assn. 42, 40 (1950)

7. Camp, Dresser and McKee
Report on Clarion River Pollution Abatement
Commonwealth of Pennsylvania Department of Health
1-196 (1949)

8. Love, J. K.
"Water Quality in the Middle Atlantic States".
J. Am. Water Works Assn. 42, 857 (1950)

9. McDill, Bruce M.
"Mobile Laboratory Survey of the Miami River".
This Journal 22, 1464-74 (1950)

10. Sanderson, Wallace W.
"Operation of a Field Laboratory Unit in Water Pollution Surveys".
This Journal 22, 1475-81 (1950)

Reproduced from best available copy.

REVIEW OF LITERATURE ON ANALYTICAL METHODS - 1950

Buswell et al.[11, 12] emphasize the fact that interpretation of B.O.D. data has been complicated by the occurrence of nitrification within the five-day period. They found that 97 per cent nitrification could be accomplished in five days when an actively nitrifying seed was present. In order to determine the various forms of nitrogen present as well as the dissolved oxygen, a two-compartment incubation vessel was used. The contents of the two compartments were mixed by inversion before running the necessary analyses.

In an attempt to suppress nitrification in the B.O.D. test, Mohlman et al.[42] studied various modifications, which included acid and heat pasteurization and the addition of chromium. The latter appeared to affect the entire flora and fauna present. Acid pasteurization followed by pH adjustment and reseeding seemed to conform more closely to the desired distinction between nitrifying and non nitrifying samples.

Lewin[37] made a detailed study of the factors involved in the determination of B.O.D. The factors studied included temperature variation, bottle size,

dilution water, nitrification and reagents used.

In order to overcome the toxic effects of industrial wastes on the bacterial seed present in a B.O.D. bottle, Borden and Woodcock[9] carried out a reseeding procedure in a special oxygen-free box. In one procedure, the B.O.D. bottles were reseeded daily and in the other, at the end of 24 and 48 hours. By this technique, higher B.O.D. values were obtained than with the normal procedure. Strong et al[60] and Swope and Kenna[64] studied the B.O.D. of a number of organic compounds which are found in industrial wastes, such as aldehydes, acids, formates, amines, etc. It was found that with those compounds normally toxic to bacteria, the B.O.D. increased with increasing dilution, a phenomena which has been noted by other investigators.

Swango and Lamb[62] describe an apparatus in which several dilutions may be made for the B.O.D. test with a minimum of aeration. They also claim that dilutions can be made in less time than with the ordinary procedures used. Wolfe[76] constructed a nomograph for calculating the proper dilutions, which is based on the probable B.O.D. of the sample.

The question of using the proper seed for the determination of the B.O.D. of industrial wastes is considered by Gehm[24] in connection with pulp and paper mill wastes. He concludes that the organisms contained in the bottom sediment of the receiving stream are best suited for an inoculating media. Sawyer et al[51] propose the use of C.P. glucose and glutamic acids as primary standards in the B.O.D. test.

Interest was continued on the determination of Oxygen Consumed and its relationship to B.O.D. Rhame[45, 46] discussed the use, interpretation and interelationship of B.O.D. and Oxygen Consumed. He also presented the correlation he obtained between the ultimate B.O.D. calculated from three and six day observations and the Oxygen Consumed as determined by a dichromate method. He corrected the Oxygen Consumed values by subtracting a factor, obtained by multiplying the NH_3-N by 2.61.

Schroeder[54] modified the alkaline permanganate method of Oxygen Consumed by adding nickel nitrate which he claims acts as a catalyst in the back titration of excess permanganate. Skopentsev[56] used a mixture of potassium and silver chromates and chromium trioxide in a sulfuric acid solution for the oxidation of organic material in water. He states the 30-150 gamma of organic

carbon can be accurately determined by this method. In some of the dichromate oxygen consumed methods the excess dichromate is titrated with ferrous salts using barium diphenyl amine sulfonate as an indicator. Swaine[61] pointed out that when 0.1 N dichromate is used, an end-point correction of 0.3 ml. should be applied.

Cameron[13] discussed the factors involved in the determination of dissolved oxygen by the Rideal-Stewart method in the presence of industrial wastes. He recommends that when gas liquor is present the Rideal-Stewart modification be replaced by the Alsterberg modification of the Winkler procedure.

Arnott et al[3] determined traces of dissolved oxygen by treating a 1000 ml. sample by the regular Winkler procedure. The liberated iodine was extracted with CCl_4. To the extract was added an excess of 0.02 N $Na_2S_2O_3$ and the excess determined by back-titration with 0.02 N I_2. A maximum probable error of $\pm$ 0.002 ml. of oxygen is claimed. Another approach to the dissolved oxygen determination was made by Gad[22] who treated the sample with $MnCl_2$ and NaOH. The supernatant was siphoned off and the precipitate treated with sodium pyrophosphate and H_2SO_4. The manganic ion was then titrated with $FeSO_4$, using

diphenylamine as an indicator. In waters containing industrial wastes in which normally the hypochlorite modification would be used, Seaman and Allen[55] used a polarographic method. Higher dissolved oxygen values are claimed for this method by the authors. Pieters and Hanssen[44] used a colorimetric method in which the intensity of the blue starch-iodide color was determined spectrophotometrically.

Continued interest was shown during the year in the determination of the various forms of nitrogen. Johnson and Ulrich[33] oxidized the organic material present with H_2O_2 before carrying out the nitration of phenoldisulfonic acid in the determination of nitrates. These authors as well as Taras[66] used NH_4OH instead of KOH for the color development. Taras[66] removed chlorides by precipitation with a silver salt and when the colors were compared visually, 2.0 ml. of phenol disulfonic acid was added to each standard. Barnes[6] as well as Holler and Huch[29] used the isomeric xylenols in the nitrate determination. The former nitrated the xylenol in an acetic acid solution, then extracted the mixture with toluene. The toluene layer was made alkaline and the developed color determined photometrically. A sensitivity of 0.1 gamma of nitrate N is claimed. The latter authors carried out the nitration

in an H_2SO_4 solution and steam distilled the nitrated xylenol into caustic. Several other workers (2, 23, 21) tried various modifications of the brucine method for the nitrate determination, and all noted considerable interference in the use of this method. Sanchez (50) and Ubaldini and Guerriere (70) used other methods for determining nitrates in the presence of nitrites. The latter workers first converted the nitrites to nitromethane which was extracted with CCl_4 or $CHCl_3$.

The determination of Kjeldahl nitrogen was also investigated by many workers. Kirk (34) considered many of the factors involved in the determination of Kjeldahl nitrogen, especially the factors concerned with the digestion process. Day et al (14) and Doyle and Omoto (16) were primarily concerned with the determination of microquantities of Kjeldahl nitrogen. Instead of using the conventional absorbents for the distilled ammonia, Blom and Schwartz (8) used nickel ammonium sulfate and titrated the excess to the methyl red endpoint. Machemer and McNapp (38) claim that steam distillation of the NH_3 has advantages over the conventional methods. A 15-fold excess of caustic was found to be sufficient for rapid and complete distillation of the NH_3. Klein (35) used an

indicator mixture composed of bromcresol green and methyl red in the back titration of the excess boric acid. Direct nesslerization of the NH_3-N in sewage instead of distillation was used by Houlihon[30] who claims that comparable results can be obtained. Errors caused by the use of NaOH were avoided by substituting sodium hexametaphosphate.

In the determination of grease in sewage sludges, Stephenson[59] dehydrated the grease with $MgSO_4 \cdot H_2O$ and then extracted it with petroleum ether.

The metallic ions are of importance not only from the standpoint of drinking water standards but also in industrial wastes and sewage treatment. Copper was determined in micro-quantities by the use of a pyridine-salicylic acid reagent by Gordieyeff[27]. Delavault and Irish[15] used dithiozone in an ammoniacal solution for the detection of copper in natural waters.

Smith et al[57] state that in the determination of aluminum with aluminon that the pH of the final mixture is important. They discuss extensively the preparation and conditions under which aluminon must be used. Back and Raggio[5] in using the Alizarin-S method for the determination of aluminum found that in the absence of calcium, hydroxylamine-HCl would eliminate interference from ferric

iron.

Adamovich[1] found that from 5-20 p.p.m. of magnesium could be determined by varying the amount of titan yellow used, depending upon the amount of magnesium present. Schraibman[53] also studied the factors involved in using titan yellow for the determination of magnesium. He obtained the best results when the NaCl concentration was 6.0 grams per liter and the NaOH was 0.2 N. Hulth[31], in separating calcium from magnesium when more than 25 per cent magnesium is present, adds the solution containing the calcium and magnesium to an aqueous solution of ammonium oxalate which is 0.05 N in acetic acid. Ringbom and Meaikonto[49] describes a method for determining calcium in which the sample is titrated with sodium fluoride. Ferric thiocyanate is used as an indicator. The optimum pH is 2.5 - 3.5.

Another metal that is of sanitary significance is chromium. Many methods have been proposed for its determination in recent years. LaCroix and Labalade[36] used KIO_4 instead of the usual bismuthate and persulfates as oxidizing agents. Urone and Anders[71] carried out the oxidation of the trivalent chromium with alkaline-bromate. However, they use NaOH instead of NH_4OH, resulting in a higher pH and more complete oxidation.

Several papers [19, 65, 32] were published dealing with the analytical procedures to be used in the evaluation of industrial wastes and sewage treatment plant efficiencies. Eckenfelder and Hood [18] followed the course of oxidation of sewage by means of alkalinity measurements. The latter authors [17] as well as Orland [43] discuss the tests to be applied in following the efficiency of a sewage treatment plant. Riehl and Will [47] reviewed the analytical determination of metals affecting sewage treatment. Among the determinations discussed are those for iron, copper, nitrate, chromium, zinc, cadmium and cyanide.

Hach [28] described a "drop" method for the determination of hardness, alkalinity, chlorides, sulfates, etc. in water. With proper precaution, an accuracy approaching five per cent can be obtained. West et al [73] discussed the application of flame spectrophotometry in the analysis of water samples. The occurrence of lead in drinking water has long been of sanitary significance. The usual dithiozone method for its determination is subject to many interferences, but, Buczowska [10] describes a method for its determination in which iron, magnesium, copper and zinc do not have to be removed.

Bates et al [7] studied various pH standards and concluded that the present buffers give errors of -0.02 to -0.05 at pH values above 11.0 and $\pm$ 0.03 below pH 2.5.

They list several buffers that they recommend as standards. Tuddenham and Anderson[69] developed a calcium chloride-hydroxide system that can be used in the pH range 11.0 to 12.65.

McConnell and Ingols[40] modified the "Standard Method" sulfate determination using benzidine hydrochloride so that greater accuracy could be obtained and in which the range of sulfate concentration to be determined is increased.

The Versenate Method for the determination of hardness in water has been widely accepted. Goetz et al[25] studied the stability of this reagent and found that less than one per cent loss in strength occurred over a period of four months at pH 4.25 to 5.0.

In the measurement of low turbidities, Matheson[39] describes a double-cell photoelectric trubidimeter which operates from a storage battery.

In the determination of chlorides and bromides with $AgNO_3$, Schafer[52] uses N-methyldiphenylamine red as an adsorption indicator. At the equivalence point the color changes sharply from a slight violet tinge to a red-violet color. Stalzer et al[58] found that the presence of protective colloids such as gelatin, dextrin, etc. enabled more precise results to be obtained in the chloride determination. Swift et al[63] propose a modification of

the Volhard Method in which the Cl^- is titrated with $AgNO_3$ in a neutral or dilute HNO_3 solution to the clear point. $FeCl_3$ is then added and the mixture titrated with HCNS to a pink color. The excess HCNS is titrated with $AgNO_3$ to the disappearance of the pink color.

Willard and Horton[74] made an exhaustive study of the various indicators that could be used in the titration of fluoride with thorium nitrate. These same authors[75] describe the fluorometric determination of fluoride in which quercetin is used as an indicator. The titration is carried out at pH 3.0 in a 50 per cent alcohol solution. From 0.1 to 40.0 mg. of fluoride can be determined by varying the procedure.

Thrun[68] used Eriochromecyanine R.C. in the colorimetric determination of fluoride. When interfering ions such as Fe (1 p.p.m.), Ca (above 106 p.p.m.) and SO_4 (760 p.p.m.) are present the distillation procedure must be used. The precision in the lower fluoride concentration is less than 0.05 p.p.m. and in the higher range 0.25 p.p.m.

A method for the determination of free chlorine or bromine was proposed by Milton[41]. It is based on the formation of cyanogen chloride or bromide which is

reacted with a pyridine-benzidine reagent. Golubev[26] reacted free chlorine with tris (p-dimethylaminophenyl) methane trihydrochloride and obtained a violet color. The color will also develop in the presence of chloramines if the solution is first boiled. Taras[67] describes a simplified method for the calibration of photometric instruments for the determination of residual chlorine. With the increased use of chlorine dioxide methods have had to be developed for the determination of the various entities present. Aston[4] discussed the use of ClO_2 and the methods used in determining the residuals present.

The errors encountered in the determination of cyanide have been subjected to further work. Urusovskaya and Zhilina[72] determined cyanide by titration of the ammoniacal solution with nickel ammonium sulfate using dimethylglyoxime as an indicator. When all of the cyanide is complexed with the nickel, the red color of nickel glyoxime appears.

Phenol and its homologues are constituents of many industrial wastes and quite often are the cause of tastes and odors in drinking water supplies. A number of methods have been proposed for the determination of phenolic

compounds. Ettinger and Kroner[20] and Riehl and Will[48] discuss the techniques first necessary for separation of such compounds and the subsequent analytical procedures used in their quantitative determination.

References *

1. Adamovich, V. I.
"Determination of Magnesium in Water by Colorimetric Titration".
Zavodskaya Lab. 13, 935-7 (1947), C.A. 44, 3636

2. Alekin, O. A. and Chornovskaya, E. N.
"Determination of the Nitrate Ion by the Noll Method".
Voprosy Gidrokhim, No. 32, 74-80 (1946),C.A. 44, 8571

3. Arnott, J., McPheat, J. and Ling, F. B.
"Estimation of Dissolved Oxygen in Deaerated Water".
Engineering 169, 553-5 (1950)

4. Aston, R. N.
"Developments in the Chlorine Dioxide Process".
J. Am. Water Works Assn. 42, 151 (1950)

5. Back, Jose M. and Raggio, Juan A.
"Colorimetric Determination of Small Quantities of Aluminum in Water".
Rev. obras sanit. nacion 13, No. 132, 28-32 (1949).
C.A. 44, 10971.

6. Barnes, H.
"Modified 2, 4-Xylenol Method for Nitrate Estimation".
Analyst 75, 388-91 (1950)

7. Bates, R. G., Pinching, Gladys G. and Smith E. R.
"Government Develops New pH Standards".
Sewage and Industrial Wastes Engineering 21, 615-16 (1950)

8. Blom, Jakob and Schwartz, Birgit
"The Direct Titration of Ammonia in Kjeldahl Determinations with Nickel Ammonium Sulfate Solutions as Absorbent".
Acta, Chem. Scand. 3, 1439-40 (1949), C.A. 44, 10575

9. Borden, George C., Jr., and Woodcock, Irene
"Reseeding B.O.D. Bottles".
Tappi, 32, 506-16 (1949)

*Since this review was prepared for publication in Sewage and Ind. Wastes Jour. "This Journal" refers to the Sewage Works Journal".

10. Buczowska, Zofia
"Colorimetric Method for Lead Determination in Water".
Gas, Woda, i. Tech. Sanit. 24, 99-102 (1950)
C. A. 44, 8570

11. Buswell, A. M., Van Meter, Irene and Gerke, J. R.
"Study of the Nitrification Phase of the B.O.D. Test".
This Journal 22, 508-513 (1950)

12. Buswell, A. M., Van Meter, Irene and Gerke, J. R.
"Study of the Nitrification Phase of the B.O.D. Test
II. Development of an Incubation Vessel for Multiple
Determinations".
This Journal 22, 1297-1301 (1950)

13. Cameron, W. M.
"Dissolved Oxygen Tests".
Inst. Sewage Purif., J. and Proc. (1947), Pt. I,
210-12

14. Day, Harry G., Bernstorf, Eileen and Hill, R. T.
"Improvements in Microaeration Technique for the
Determination of Kjeldahl Nitrogen".
Anal. Chem. 21, 1290-91 (1949)

15. Delavault, R. and Irish, R.
"Use of Dithizone in Ammoniacal Aqueous Solution".
Compt. Rend. Acad. Sci. Paris 229, 1079-31 (1949)

16. Doyle, W. L. and Omoto, J. H.
"Ultramicrodetermination of Nitrogen".
Anal. Chem. 22, 603-4 (1950)

17. Eckenfelder, W. W., Jr., and Hood, John W.
"Critical Evaluation of Routine Sewage Analysis".
Water and Sewage Works 97, 138-41 (1950)

18. Eckenfelder, W. W., Jr. and Hood, John W.
"Alkalinity Significance in Sewage Oxidation".
Water and Sewage Works 97, 189-93 (1950)

19. Ettinger, M. B.
"Analytical Procedures for Industrial Wastes".
Water and Sew. Works 97, 292-94 (July 1950)

20. Ettinger, M. B. and Kroner, R. C.
"Determination of Phenolic Materials in Industrial Wastes".
Proc. 5th Ind. Waste Conf., Purdue U. 345-59 (1949)

21. Fungairino, L. Villanua and Rodicio, M. Hernandez
"Revision of Methods for the Assay of Nitrates in Water. II. The Brucine Reaction".
Anales bromatol. 2, 55-63 (1950). C.A. 44, 10970

22. Gad, George
"Titrimetric Determination of Dissolved Oxygen in Water Without the Use of Iodine-Containing Reagents".
Gesundh - Ing. 69, 22-23 (1948). C.A. 44, 8571

23. Gad, George, Knetsch, Margaret and Schlichting, Hilde
"Determination of Nitrate in Water".
Gesundh. - Ing. 69, 137-9 (1948). C.A. 44, 8571

24. Gehm. H. W.
"Adaptation of the B.O.D. Test to Pulp and Paper Mill Wastes".
Tappi, Vol. 33, No. 3, 124 (1950)

25. Goetz, Charles A., Loomis, T. C. and Diehl, Harvey
"Total Hardness in Water, Stability of Standard Disodium Dihydrogen Ethylenediaminetetraacetate Solutions".
Anal. Chem. 22, 798-99 (1950)

26. Golubev, T. I.
"New Method of Chlorine Determination in Water".
Gigiena, (U.S.S.R.), 12, No. 10, 27-28 (1947)

27. Gordieyeff, V. A.
"Colorimetric Determination of Copper with Pyridine and Salicylic Acid".
Anal. Chem. 22, 1166-69 (1950)

28. Hach, Clifford C.
"Drop Count System of Water Analysis".
Water and Sewage Works 97, 415 (1950)

29. Holler, Albert C. and Huch, Rita V.
"Colorimetric Determination of Nitrates and Nitric Acid Esters. Isomeric Xylenols as Reagents".
Anal. Chem. 21, 1385-89 (1949)

30. Houlihon, J. E.
"Rapid Method for the Estimation of Ammonia Nitrogen in Sewages".
Analyst 74, 511-13 (1949)

31. Hulth, Tore
"Separation of Calcium from Magnesium by the Oxalate Method".
Anal. Chem. 21, 1221-26 (1949)

32. Ingols, R. S., Hildebrand, J. C., and Ridenour, G.M.
"Measuring the Strength of Sewage and Trade Waste B.O.D. or Oxygen Consumed".
Water and Sew. Works 97, 21-27 (1950)

33. Johnson, C. M. and Ulrich, Albert
"Determination of Nitrate in Plant Material".
Anal. Chem. 22, 1526-29 (1950)

34. Kirk, P. L.
"Kjeldahl Method for Total N".
Anal. Chem. 22, 354-58 (1950)

35. Klein, L.
"Semi-micro Determination of Nitrogen in Sewage Sludges".
J. Inst. Sewage Purif., I, 223-25 (1947)

36. Lacroix, S. and Labalade, M.
"Colorimetric Determination of Manganese and Chromium".
Anal. Chim. Acta 3, 262-71 (1949)

37. Lewin, V. H.
"Routine Estimation of Biochemical Oxygen Demand".
Inst. Sewage Purif., J. and Proc., II, 140-55 (1949)

38. Machemer, Paul E. and McNabb, Wallace M.
"The Semimicrodistillation of Ammonia into Four Per Cent Boric Acid Solution. Accuracy and Precision of the Method".
Anal. Chim. Acta, 3, 428-32 (1949). C.A. 44, 10596.

39. Matheson, D. H.
"A Sensitive Turbidimeter".
Water and Sewage Works 97, 206-8 (1950)

40. McConnell, J. W. and Ingols, R. S.
"Sulfate Ion Determination with Benzidine Hydrochloride".
Water and Sewage Works 97, 330-32 (1950)

41. Milton, R. F.
"Test for Free Chlorine or Bromine".
Nature 164, 448 (1949)

42. Mohlman, F. W., Hurwitz, E., Barnett, G. R. and Kramer, H.
"Experience with Modified Methods for B.O.D.".
This Journal 22, 31-39 (1950)

43. Orland, Herbert P.
"Laboratory Tests for Small Sewage Treatment Plants".
This Journal 22, 245-50 (1950)

44. Pieters, H.A.J. and Hanssen, W. J.
"Spectrophotometric Determination of Traces of Oxygen in Water".
Anal. Chim. Acta 2, 712-26 (1948)

45. Rhame, George A.
"B.O.D. or C.O.D." - A Commentary
Water and Sewage Works 97, 179-81 (1950)

46. Rhame, George A.
"Some Further Observations on the C.O.D. Test".
Water and Sewage Works 97, 344-45 (1950)

47. Riehl, M. L. and Will, E. G.
"Analytical Determination of Metals Affecting Sewage Treatment".
Proc. 4th Ind. Waste Conf., Purdue Univ. Eng. Bull. Extension Ser. No. 68, 211-22 (1949)

48. Riehl, M. L. and Will, E. G.
"Analytical Procedures for the Determination of Phenols in Water and Trade Wastes".
This Journal 22, 190-95 (1950)

49. Ringbom, A. and Merikanto, B.
"Determination of Calcium".
Acta Chim. Scand. 3, 29 (1949)

50. Sanchez, Joan A.
"Estimation of Nitrite and Nitrate in Drinking Water".
Mon. farm y terap (Madrid) 56, 61-3 (1950)
C. A. 44, 5041

51. Sawyer, C. N., Callijas, P. and Moore, M.
"Primary Standards for B.O.D. Work".
This Journal 22, 26-30 (1950)

52. Schafer, Harold
"N-Methyldiphenylamine Red as Adsorption Indicator in the Argentometric Determination of Chloride and Bromide in an Acid Solution".
Z. Anal. Chem. 129, 222-29 (1949)

53. Shraibman, S. S.
"Colorimetric Determination of Magnesium with Titan Yellow".
Zavodskaya Lab. 13, 930-34 (1947). C.A. 44, 3401

54. Schroeder, H.
"Determination of Organic Matter in Water and Sewage with Alkaline Permanganate Solution".
Gesundh.-Ing. 71, 220-21 (1950), C.A. 44, 10973

55. Seaman, William and Allen, William
"Polarographic Determination of Dissolved Oxygen in Water Containing Industrial Effluent".
This Journal 22, 912-21 (1950)

56. Skopintsev, B. A.
"Determination of Organic Carbon in Fresh Water".
Zhur. Anal. Khim. 4, 192-98 (1949)

57. Smith, W. H., Sager, E. E. and Siewers, I. J.
"Preparation and Colorimetric Properties of Aluminon".
Anal. Chem. 21, 1334-38 (1949)

58. Stalzer, Robert F., Dillon, Edith Staff and Vosburgh, W. C.
"Protective Colloids in the Volumetric Determination of Chloride Ion".
Anal. Chem. 22, 952-53 (1950)

59. Stephenson, R. J.
"Estimation of Grease in Sewage Sludges".
Analyst 74, 257-60 (1949)

60. Strong, E. R., Shrewsbury, C. J., and Hatfield, R.
"B.O.D. of Some Organic Compounds Present in Chemical Wastes".
Anal. Chem. 22, 199-200 (1950) (an abstract)

61. Swaine, D. J.
"Barium Diphenylamine Sulfonate as an Oxidation Reduction Indicator".
Roy. Australian Chem. Inst., J. and Proc. 17, 234-88 (1950) C.A. 44, 10576

62. Swango, W. H. and Lamb, C. B.
"Dilution Technique for B.O.D. Test".
This Journal 22, 939-40 (1950)

63. Swift, Ernest H., Arcand, G. Myron, Lutwack, Ralph and Meier, Dale J.
"Determination of Chloride. Modification of the Volhard Method".
Anal. Chem. 22, 306-08 (1950)

64. Swope, H. Gladys and Kenna, Marita
"Effect of Organic Compounds on B.O.D.".
This Journal 21, 467-63 (1950)

65. Swope, H. G. and O'Callaghan, M.
"Determination of Metals in Industrial Waste, Part 1, Iron and Copper".
Water and Sewage Works 97, 125-28 (1950)

66. Taras, Michael J.
"Phenoldisulfonic Acid Method of Determining Nitrate in Water-Photometric Study".
Anal. Chem. 22, 1020-22 (1950)

67. Taras, M. J.
"Simplified Calibration of Photometric Instruments for Residual Chlorine".
Water and Sewage Works 97, 404 (1950)

68. Thorun, Walter E.
"Rapid Methods for Determining Fluoride in Water".
Anal. Chem. 22, 913-22 (1950)

69. Tuddenham, W. M. and Anderson, D. H.
"Buffer for High pH Measurements".
Anal. Chem. 22, 1146-48 (1950)

70. Ubaldini, I. and Guerrieri, F.
"Determination of Nitrates in the Presence of Large Amounts of Nitrites".
Ann. Chim. Appl. 38, 702-08 (1948)

71. Urone, P. F. and Anders, H. K.
"Determination of Small Amounts of Chromium in Human Blood, Tissue and Urine".
Anal. Chem. 22, 1317-21 (1950)

72. Urusovskaya, L. G. and Zhilina, P. I.
"Cyanide Determination by Titration with Nickel Ammonium Sulfate".
Zavodskaya Lab. 15, 740-41 (1949). C.A. 44, 481 (1950)

73. West, P., Folse, P. and Montgomery, D.
"Application of Flame Spectrophotometry to Water Analysis".
Anal. Chem. 22, 667 (1950)

74. Willard, H. H. and Horton, C. A.
"Indicators for Titration of Fluoride with Thorium".
Anal. Chem. 1190-94 (1950)

75. Willard, H. H. and Horton, C. A.
"Photofluorometric Titration of Fluoride".
Anal. Chem. 22, 1194-97 (1950)

76. Wolfe, John R.
"Nomograph for Determining Proper Dilution in B.O.D. Test".
Water and Sewage Works 97, 122 (1950)

A REVIEW OF LITERATURE ON RADIOACTIVE WASTES -1950

In discussing the peace-time and wartime effects of nuclear fission operation, Dr. Abel Wolman[47] has aptly said that The Effects of Atomic Weapons[43] should be required reading for at least a selected few in every department of health in the country. Similarly Health Services and Special Weapons Defense[42] should be required reading to stimulate the rapid technical training necessary to cope with potential radiation hazards.

During the development of the first experimental reactor, the potential radiation hazards of fission were recognized. Three tolerance limits had been established and accepted as a working basis for occupational exposure prior to 1945[10]. Based on radiation effects from radium and x-ray experience they were (a) 0.1 Roentgen per day for external α and gamma radiation, (b) 1×10^{-14} curie of radon per cubic centimeter of air in working rooms and (c) a maximum of 0.1 microgram of radium deposited in the body of a radium dial painter.

Tentative rules and regulations for the atomic energy industry were prepared[46] concerning the maximum permissible levels of body exposure to various types of

nuclear radiation; tolerance levels for air, water, and surface contamination; radiation monitoring service to determine when special protective clothing, masks, respirators, and airline hoods would be used; disposition or burial of radioactive thrash, unwanted material and equipment; and safety precautions in the shipment and transfer of radioactive materials.

The water monitoring procedures at Clinton Laboratories were reviewed by H. M. Parker (29) to assess the radiation hazards of fission products in the waste water. Animal experimentation had shown that certain elements in fission product waste were deposited in the bone and their ingestion would increase the radiation hazard to bone marrow. The daily ingestion tolerance of a single radioactive substance based on imbibing 3 liters of contaminated water per day was established at 0.21 microcuries of strontium, 9.3 microcuries of barium, 10.2 microcuries of ruthenium, and 3.6 microcuries of mixed fission product. Only 2.4 per cent of the activity of fission product waste overflow water after chemical precipitation, dilution, and settling was associated with suspended floc. The soluble or filtrate radioactivity consisted of 0.27 per cent barium plus strontium, 58.5 per cent zirconium, 25.6

per cent columbium, 1.69 per cent ruthenium, and less important fission elements. Thus, a tolerance concentration for ingestion could be calculated and compared with the tolerance concentration for external radiation based on total immersion of the body for 24 hours per day. The tolerance concentration for ingesting this filtered water was calculated to be 21.6 microcuries per liter as compared to 8.6 microcuries per liter for the external radiation due primarily to gamma rays. For the combined radiations the tolerance concentration of this water was estimated to be 1.8 microcuries per liter.

Subsequently, ingestion and external tolerance limits based on more accurate estimations of the "effective half life" of elements having alpha, beta and gamma radiations were published by K. Z. Morgan (24), and Forrest Western (45). These "tolerance" concentrations are based on subjecting the critical tissue to not more than 1/10 to 1/100 of the maximum permissible exposure of 0.1 Roentgen equivalent per day. A few of the "tolerance" concentrations in drinking water are: 0.58 microcurie per liter for Sr^{90} Y^{90} (0.0035 p.p.b.), 3.7 uc/li for Ba^{140}, La^{140}(0.0005 p.p.b.), 1600 uc/li for Cb^{95} (0.006 p.p.b.), 130,000 uc/li for Pr^{143} (2 p.p.b.)

and 5.4 uc/li for Cs^{137} (0.0065 p.p.b.).

H. M. Parker [28] estimated that if the permissible amount of plutonium 239 deposited in the bone was taken to be 0.5 micrograms and the absorption of Pu from the gastrointestinal tract was in the order of 0.05 per cent, then the tentative permissible concentration of Pu in the drinking water would be 0.01 p.p.b.

The problems and research programs on radioactive waste disposal were discussed by Ayres [6], Beers [7], Gorman and Wolman [15], Gorman [16], Morton [26], Parkhurst [30], Placak and Morton [31 & 32], Setter [37], Western [45], at a symposium [3] and elsewhere [4, 41 and 44]. Placak and Morton [31] present the latest permissible concentration of a dozen radioisotopes in air and water which is to be published by the National Research Council in a Handbook of Nuclear Instruments and Techniques. These permissible concentrations are compared with the natural radioactivity of U.S. waters. The studies and research teams working on radioactive waste problems are listed and discussed.

The possibilities of biological treatment methods for the removal of radioactive elements from dilute wastes were discussed by C. C. Ruchhoft [35]. A synthetic waste containing 1.4 p.p.b. Pu^{239} (approximately 100,000 alpha counts per minute per liter) was treated in a laboratory

by the activated sludge process. Although the process achieved a 96 per cent removal of alpha activity in 24 hours of treatment, the effluent quality fell short of the goal of 0.001 p.p.b. or 70 counts per minute per liter. A two stage treatment study using supplementary nutrients to feed the zoogles organisms was underway. This study was reported in greater detail by J. F. Newell[27].

The Atomic Energy Commission retains the power of control over the use of radioisotopes and the disposition of radioactive wastes. As a guide to off-commission users, the Isotopes Division of the AEC provides interim recommendations for the safe disposal of radioactive wastes[1]. The recommendations for radio-iodine permit disposal by dilution with water or stable iodides and water provided (a) regular radiation surveys of plumbing fixtures are made, particularly before their repair, (b) a maximum of 200 millicuries are disposed per week and (c) the flow in the main sewer of the institution is sufficient to dilute the radio-iodine to 0.5 microcuries per liter, or, if one gram of potassium iodide is added to each millicurie of radio-iodine, the radioactivity should not exceed 10 microcuries per liter.

Isotopic dilution or the adding of relatively huge quantities of stable isotope to a radioisotope in the same chemical form was considered a feasible method of preventing hazards due to ingestion. Recommendations for the safe disposal of P^{32}, C^{14} and other isotopes were also given. Butrico[8] concluded that the Interim Recommendations were ultra safe when applied to a Massachusetts hospital. However, K. G. Scott[36] estimated that the external radiation hazard due to the disposal of radio-iodine according to the Interim Recommendations might be significant. The estimations considered radiations from park grounds that were fertilized with sewage sludge from a treatment plant receiving radio-iodine hospital wastes. It was presumed that the radio-iodine in the sewage would be absorbed by settleable solids and concentrated in the chemically conditioned and vacuum filtered sludge.

Wastes from Atomic Weapons

Radioactive hazards and air, water, and surface decontamination problems associated with the use of atomic weapons appear foreboding[5, 11, 42 & 43]. Certainly the current maximum permissible exposure of 0.3 Roentgens per week of X or gamma radiation[23] would not be a realistic tolerance for short time

exposures. According to Col. Cooney[11] a full body irradiation in the order of 25 to 100 Roentgens has been given to patients for treatment of various conditions and that an exposure to 200 Roentgens may be considered an acute dose, which may cause radiation sickness in 50 per cent of humans. Further guidance is needed on correlating the risk attached to varying levels of internal and external exposure.

The gamma radiation from the fission products of a single "nominal" atom bomb[43] decreases rapidly after detonation due to radioactive decay. Nevertheless, the residual radioactivity after one week and one year from the time of detonation has been estimated to be 13 million and 110,000 curies, respectively. Depending on the altitude of detonation a varying percentage of fission products will contaminate the area in the vicinity of the bomb burst. The blast effects of the bomb are most devastating at relatively high altitudes of detonation. In this case the fission products are dispersed in the upper atmosphere and local radiation hazards immediately following the bomb burst are relatively minor. However, the detonation of the bomb at low level, under ground, or under water may result

in prolonged problems of radiation hazard and surface contamination.

Water supplies and sewage containing fission products and decontaminating fluids will require treatment necessary for the removal of the more hazardous fission products as differentiated from the less harmful radioactive isotopes of short "effective half life".

In the fission of unstable heavy elements a variable yield of fission product results from fast and slow fission of U^{235}, Pu^{239}, etc. (5, 12 & 21). The radioactive isotopes have specific rates of decay varying from half lives of seconds to years and each isotope may decay through three or four generations of daughter isotopes. The concentration of any particular isotope depends on the time since fission occurred. Short lived isotopes, which represent a large fraction of the yield at the time of fission, decay to other isotopes and, conversely, long lived radioisotopes, which represent a minor fraction of the yield at the time of fission, become important fractions at a later date or become important due to the accumulation of daughter isotopes.

The more important radioactive isotopes remaining some weeks or months after fission are Sr^{89}, Sr^{90}, Y^{90},

Zr^{95}, Cb^{95}, Element 43^{99}, Ru^{103}, Ru^{106}, Rh^{106}, Sn^{121}, Sb^{125}, I^{131}, Cs^{137}, Ba^{140}, La^{140}, Ce^{141}, Pr^{143}, Ce^{144}, Pr^{144}, Nd^{147}, induced activity in elements near the bomb burst and residual alpha emitting heavy elements[5].

Safety measures and instruments for monitoring personnel, contaminated areas and laboratories have been reviewed by Andrews[2], Dauer[13], Ingram[19], G. Morgan[23], K. Z. Morgan[25], Rodger[34] and in chapters on health physics and instrumentation in nuclear physics text books[5, 12 & 21]. Special laboratory safety procedures and equipment have been described by Tompkins[38 & 39].

Texts on the chemistry and separation of the heavy metals, rare earths, and other fission products have been or are being released in the NNES (National Nuclear Energy Series) for publication by McGraw Hill, New York. Tompkins, Farabee, and Khym[40] developed a procedure for the simultaneous radiochemical analysis of barium, strontium and rare earths in urine by phosphate precipitation, the use of a cation exchanger to remove phosphate ions, separation of radioactive ions by elution followed by chromate precipitation to separate strontium and yttrium from calcium and magnesium. Studies were reported on the effect of pH on the solubility of rare earth and thorium phosphates and polyphosphates[9], the purifica-

tion of protoactinium by anion exchange resins[20], a rare earth separation by anion exchange[18], the separation of hafnium from zirconium by absorption on silica gel[17], the separation and mounting of fission elements by electrodeposition[22], a precision method of counting radioactive liquid samples mounted below a thin window G-M tube[14], and a portable scintillation spectrometer consisting of a 100 gram alkali halide crystal and photomultiplier which has a detection sensitivity of 10^{-10} r/sec[33].

An increasing amount of nuclear science literature is being declassified. These AEC documents and the Nuclear Science Abstracts can be obtained from the Technical Information Branch, Atomic Energy Commission, Oak Ridge, Tennessee.

References*

1. AEC
"Interim Recommendations for the Disposal of Radioactive Wastes by Off-Commission Users". Circular B-6, AEC Isotopes Division P.O. Box E. Oak Ridge, Tenn.
Abst. This Journal 22, 574 (1950)

2. Andrews H. L.
"Essentials of Instrumentation".
Radiological Defense Vol. 3, p 24 (1950)
U. S. Government Printing Office

3. Anon
"Waste Disposal Symposium (A Review)"
Nucleonics 4, 9 (1949)
Abst. This Journal 22, 575 (1950)

4. Anon
"Radiation Contamination in Relation to Water Supply".
American Jour. Public Health 40, 113 (1950)

5. Armed Forces Special Weapons Project
"Radiological Defense Vol. I
U. S. Government Printing Office, Oct. 1948

6. Ayres, John A.
"Radioactive Waste Disposal".
AEC Document No. AECD-2802
Declassified Jan. 31, 1950

7. Beers, Norman R.
"Living With the Atom".
Jour. A.W.W. Assoc. 42, 729 (1950)

8. Butrico, Frank A.
"Disposal of Radioactive Waste from Massachusetts General Hospital".
AEC File No. NP-1623 MIT May 19 (1950)
Nuclear Science Abst. 4, 536 (1950)

9. Buyers, A. G. and Andrieth, L. F.
"The Phosphates and Polyphosphates of the Rare Earths and Thorium".
AEC File No. NP-1435, Mar. 15 (1950)

*Since this review was prepared for publication in Sewage and Ind. Wastes Jour. "This Journal" refers to the Sewage Works Journal.

10. Cantril, S. T. and Parker, H. M.
"The Tolerance Dose"
AEC Document No. MDDC-1100
January 5, 1945

11. Cooney, James P.
"Psychological Factors in Atomic Warfare".
American Jour. Public Health 39, 969 (1949)
Radiological Defense Vol. 3, p. 110
U. S. Government Printing Office (1950)
Abst. This Journal 22, 574 (1950)

12. Cork, J. M.
"Radioactivity and Nuclear Physics".
Van Nostrand, New York, 1947

13. Dauer, M.
"The Production Procurement and Handling of Radioisotopes".
Radiological Defense Vol. 3, 114 (1950)
U. S. Government Printing Office

14. Freedman, A. J. and Hume, David
"A Precision Method of Counting Radioactive Liquid Samples".
Science 112, No. 2912, 461 (1950)

15. Gorman, A. E. and Wolman, Abel
"Nuclear Fission Operations and the Sanitary Engineer".
This Journal 21, 72 (1949)

16. Gorman, Arthur E.
"Mutual Interests Between the Water Works and Atomic Energy Industries".
Jour. N.E.W.W.A. 64, 148 (1950)

17. Hansen, R. S., Gunnar, K., Jacobs, A. and Simmons, C. R.
"The Absorption Separation of Zirconium and Hafnium".
AECU - 842
NSA 4, No. 4837, 730 (1950)

18. Huffman, E. H. and Oswalt, R. L.
"A Rare Earth Separation by Anion Exchange".
J. Am. Chem. Soc. 72, 3323 (1950)

19. Ingram, Fred R.
"Radioactivity Protection Devices".
Journal A.W.W.A. 42, 537 (1950)

20. Kraus, K. A. and Moore, G. E.
"Chemistry of Protoactinium IV"
AECD-2866
NSA 4 No. 4860, 735 (1950)

21. Lapp, R. E. and Andrews, H. L.
"Nuclear Radiation Physics".
New York: Prentice Hall, 1948

22. Lee, D. and Cook, G. B.
"The Separation and Mounting of Some Fission Elements by Electrodeposition".
AEC Document No.
AERE-C/R-430 Oct. 1949
NSA 4, No. 4860, 735 (1950)

23. Morgan, G. W.
"Surveying and Monitoring of Radiation from Radioisotopes".
Nucleonics 4, 24 (1949)

24. Morgan, K. Z.
"Tolerance Concentrations of Radioactive Substances".
Jour. Phys. C Colloid Chem. 51, 984 (1947)

25. Morgan, K. Z.
"Shipping of Radioisotopes".
Jour. Appl. Phys. 19, 593 (1948)

26. Morton, R. J.
"The Sanitary Engineer Faces New Problems from Atomic Energy Developments".
Harvard Public Health Alumini Bulletin, November 1948

27. Newell, John F.
"Exploratory Studies on the Removal of Plutonium from Liquid Wastes by Activated Sludge".
AEC Document No. AECD-2712 Oct. 4 (1949)

28. Parker, H. M.
"Tolerable Concentration of Product (Pu^{239}) in Drinking Water".
AEC Document No. AECD-2906
(Declassified June 28, 1950)

29. Parker, H. M.
"Review of Water Monitoring Procedures at Clinton Laboratories".
AEC Document No. MDDC-401
(Declassified Oct. 23, 1946)

30. Parkhurst, John D.
"Handling Radioactive Wastes in Sewers".
This Journal 22, 1073 (1950)

31. Placak, O. R. and Morton, R. J.
"Radioactive Waste Disposal".
J.A.W.W.A. 42, 135 (1950)
Abst. This Journal 22, 972 (1950)

32. Placak, O. R. and Morton, R. J.
"Proposal for Evaluating the Impact of Water Borne Radioactive Contaminants on Sanitary Engineering Facilities".
Document No. ORNL - 251, June 1949

33. Pringle, Robert W.
"A Portable Scintillation Spectrometer".
Atomics I, 49 (1950)
Nu. Sc. Abst. 4, 751 (1950)

34. Rodger, W. A.
"Atomic Wastes and Water Quality".
Journal A.W.W.A. 42, 533 (1950)

35. Ruchhoft, C. C.
"The Possibilities of Disposal of Radioactive Waste by Biological Treatment Methods".
This Journal 21, 877 (1949)

36. Scott, Kenneth G.
"Radioactive Waste Disposal - How Will It Affect Man's Economy"?
Nucleonics 6, 13 (1950)
Abst. This Journal 22, 972 (1950)

37. Setter, L. R.
"Nuclear Fission Operations - A Discussion".
This Journal 21, 72 (1949)

38. Tompkins, Paul C.
"Laboratory Handling of Radioactive Material".
AEC Document No. MDDC - 1414

39. Tompkins, Paul C.
"Laboratory Handling of Radioactive Material - Protection of Personnel and Equipment".
AEC Document No. MDDC - 1527

40. Tompkins, Paul C., Farabee, L. B. and Khym, J. X.
"Procedure for the Radiochemical Analysis of Barium, Strontium, and the Rare Earths in Human Urine".
AEC Document No. ALCD-2692
(Declassified Aug. 26, 1949)

41. USAEC
"Handling Radioactive Wastes in the Atomic Energy Program". Oct. 1949
U. S. Government Printing Office 15¢
Abst. This Journal 22, 195 (1950)

42. U. S. Civil Defense
"Health Services and Special Weapons Defense".
U. S. Government Printing Office
December 1950

43. U. S. Department of Defense and USAEC
"The Effects of Atomic Weapons".
Sept. 1950, U. S. Government Printing Office, Price $1.25

44. U. S. National Bureau of Standards
"Safe Handling of Radioisotopes".
Handbook No. 42
U. S. Government Printing Office, Price 15¢

45. Western, Forrest
"Problems of Radioactive Waste Disposal".
Nucleonics 3, 43 (1948)

46. Wirth, J. E.
"General Rules and Procedures Concerning Activity Hazards".
AEC Document No. MDDC - 2 47
(Declassified Aug. 20, 1946)

47. Wolman, Abel
"Public Health Aspects of Atomic Energy".
Am. Jour. Pub. Health 40, 1502 (1950)